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WIND TUNNEL TEST OF ACES II EJECTION SEAT WITH ANTHROPOMETRIC DUMMY IN ASYMMETRIC CONFIGURATIONS

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AMRL-TR-78-108

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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

HENNING E. VON GIERKE
Director
Biodynamics and Bioengineering Division
Aerospace Medical Research Laboratory

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Previous investigations have determined the aerodynamic forces and moments acting upon an open ejection seat and its occupant when the seat occupant was sitting symmetrically with respect to the seat axes, with his limbs in the correct "stowed" positions. The present investigation was undertaken to determine the changes in the aerodynamic forces due to deviations from this ideal position; principally off-center asymmetry and changes due to limb movement.

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SUMMARY

A number of investigators have determined the aerodynamic forces and moments acting upon an open ejection seat and its occupant. In essentially all previous cases, the seat occupant was sitting symmetrically with respect to the seat axes, with his limbs in the correct "stowed" positions. The purpose of the present investigation was to determine the changes in the aerodynamic forces due to deviations from this ideal position; principally off-center asymmetry and changes due to limb movement.

PREFACE

This report was prepared in partial fulfillment of Contract F33615-76-C-0530. The research was accomplished by Payne, Inc., 1933 Lincoln Drive, Annapolis, Maryland 21401. Peter R. Payne was the Principal Investigator.

The Air Force Technical Monitor was James W. Brinkley of the Biomechanical Protection Branch, Biodynamics and Bioengineering Division of the Aerospace Medical Research Laboratory.

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INTRODUCTION

Wind tunnel measurements of anthropometric dummies in ejection seats have been reported in previous tests (References 1 and 2). Most of these experiments were conducted with symmetric initial conditions of the test subject. The purpose of this report is to describe the effect of body asymmetry on initial static forces and moments that could lead to seat/occupant instabilities in the operational environment.

The data are important because:

(a) escapees in a real life situation do not always have perfect positioning, even during low speed escapes; and

(b) at high escape speeds, limb flailing can result in aerodynamic forces and moments quite different from those anticipated from conventional test data.

Even when qualification testing with dummies, it is not unknown for a dummy limb to become dislodged during the escape sequence, and this may be suspected to be the cause of a malfunction of the escape system. If the change in the seat/occupant aerodynamic forces could be established in such cases, then it can sometimes be established whether the "failure" of such a test was in fact due to the problem with the dummy, or to a basic problem with the escape system.

TEST OBJECTIVES AND SET UP

Test Facilities and Equipment

The University of Maryland wind tunnel is of the single return type with a rectangular working section 7.75 feet high by 11.04 feet wide. The tunnel is vented to ambient pressure at the working section, establishing the pressure reference datum. Dynamic pressure ($q = 1/2\ \rho V^2$) at maximum tunnel operating speed is 135 lb/ft^2, corresponding to a speed of 337 ft/sec.

Forces and Moments Acting on the Seat Assembly

The seats were mounted on a pedestal attached to the force and moment balance platform in the tunnel floor. Forces and moments on the seat are transmitted by mechanical linkages to the six component balance system located beneath the test section. The balancing is automatic, electrically driven, displaying six-component data at the tunnel operator's position at the central console and on a lighted number panel for plotting. All the indicated data are automatically recorded in a printout and on IBM punched cards.

Force and Moment Measurements

1. Direction of Force Measurement

   a. Lift. . . . . Vertical with respect to tunnel center line

   b. Drag. . . . . Horizontal (fore and aft) with respect to tunnel center line

   c. Side Force. . . . . Horizontal and perpendicular to fore and aft tunnel center line

2. Axes of Moment Measurement

   a. Pitching Moment . . Horizontal and through the front model support trunnion axis, at 0° yaw angle

   b. Rolling Moment. . . Horizontal with respect to tunnel center line - intersecting pitching moment axes on tunnel center line

   c. Yawing Moment . . . Vertical through center line of tunnel - intersecting pitching moment axis at front model support trunnions

Balance and Support System Limitations

Force and Moment Measurement of Basic Unit

Measurement	Range	Accuracy
Lift (lb)	0 to ±5000	±0.50 lb
Drag (lb)	0 to ±500	±0.10 lb
Side Force (lb)	0 to ±1000	±0.10 lb
Pitching Moment (ft-lb)	0 to ±1000	±0.20 lb
Rolling Moment (ft-lb)	0 to ±1000	±0.20 lb
Yawing Moment (ft-lb)	0 to ±1000	±0.20 lb

Accuracies apply to loadings of less than 10% of forces and 20% of moments. Loadings in excess of these percentages can be measured with an accuracy of one tenth of one percent (.1%). The accuracy of the tunnel velocity is ±0.5%.

The tunnel services include programs for transfer of force and moment data from tunnel axes to body axes (or indeed any other workable system of coordinates). In most aerodynamic studies these angles are small and it is customary to refer to wind axes through the body center of mass or some other geometrically convenient point as origin. In the present study, body axes are employed for gross forces and moments with the CG measured as shown in Figure 9.

Seat/Anthropometric Dummy Modifications for Wind Tunnel Testing

a. ACES II ejection seat

1. No significant modifications were made to the ACES II seat.

b. Fiftieth percentile anthropometric dummy

1. No modifications were made to the anthropometric dummy, except to add additional support to the arms in configuration H (Figure 8).

Standard Test Procedure

The standard test consisted of a yaw angle sweep (-30° to +30°) at a given angle of attack and a specified configuration. At each yaw angle, the six static forces (F) and moments (M) were recorded. These forces and moments were converted to force areas (F/q) and moment volumes (M/q) by dividing each by the dynamic pressure ($q = \frac{1}{2}\rho V^2$) . Finally a set of measurements were made to determine each configuration's center of gravity location.

RESULTS AND DISCUSSION

Description of Asymmetric Body Segment Locations

The location of various limb segments are generally referenced to the seat pivot point. If a different reference point is used it will be stated. Figures 1 - 8 illustrate the configurations employed.

Configuration A. (Figure 1)

This configuration is the "ideal" ejection posture. The head is facing forward on the center line of the seat. Both hands are firmly on the ejection handles and symmetric with respect to the center line. Both feet are also symmetric with respect to the center line.

Configuration B. (Figure 2)

In this configuration the subject's torso, hips and legs have been shifted to his right. Both hands are firmly on the ejection handles. The left foot is on the centerline of the seat. The right leg is firmly against the inside of the seat. The head is slightly off-center. Referring to Figure 2 the left hip (dimension A) is 4 inches from the inside of the seat; the left knee (dimension B) is 6-1/2 inches from the inside of the seat. The left shoulder is 1 inch from the seat back (dimension C).

Configuration C. (Figure 3)

This configuration simulates the asymmetric condition when one hand is on the ejection handle and the other hand is on the plane of symmetry of the seat. All body positions are the same as configuration A except for the right hand.

Configuration D. (Figure 4)

This configuration is similar to configuration C except that the body is again shifted to starboard. The head is slightly off-center; the left leg and left foot are approximately along the centerline. The dimensions A, B and C are the same as configuration B (Figure 2).

Configuration E. (Figure 5)

This configuration simulates a high-G deceleration with both arms and legs in a windward or forward position. The arms and legs are both symmetric about the centerline. The ankles are 42 inches forward, 7 inches above an imaginary plane parallel to the tunnel floor passing through the seat pivot point. The ankles are 10 inches (dimension A) off the centerline. The wrists are 30 inches forward, 32 inches above and 7-1/2 inches off the centerline (dimension B).

Configuration F. (Figure 6)

This configuration simulates right arm flailing. The rest of the body is approximately symmetrical (note the slight off-center position of the head) about the centerline. The right wrist is 11 inches above, 3 inches aft and 10 inches outward from the pivot point.

Configuration G. (Figure 7)

This configuration again simulates a flailing position. Both the right arm and right leg are seen away from their nominal position. The right arm has the same coordinates as configuration F. The right ankle is 16 inches forward and 3 inches below the pivot point and 7 inches off the centerline from the pivot point. The right toe is 17 inches forward, 11 inches below and 12 inches off the centerline from the pivot point.

Configuration H. (Figure 8)

This configuration simulates both arms and both legs in a flailing position. The left wrist is 11 inches above and 3 inches aft of the pivot point. The right wrist is as for configuration F. The left ankle is 16 inches forward and 3 inches below the pivot point and 7 inches off the centerline. The right ankle is the same as configuration G. Both knees are firmly against the inside of the seat. The left toe to right toe distance is 24 inches. The left heel to right heel distance is 13 inches.

Figure 1. Anthropometric dummy in ACES II ejection seat. Configuration (A)

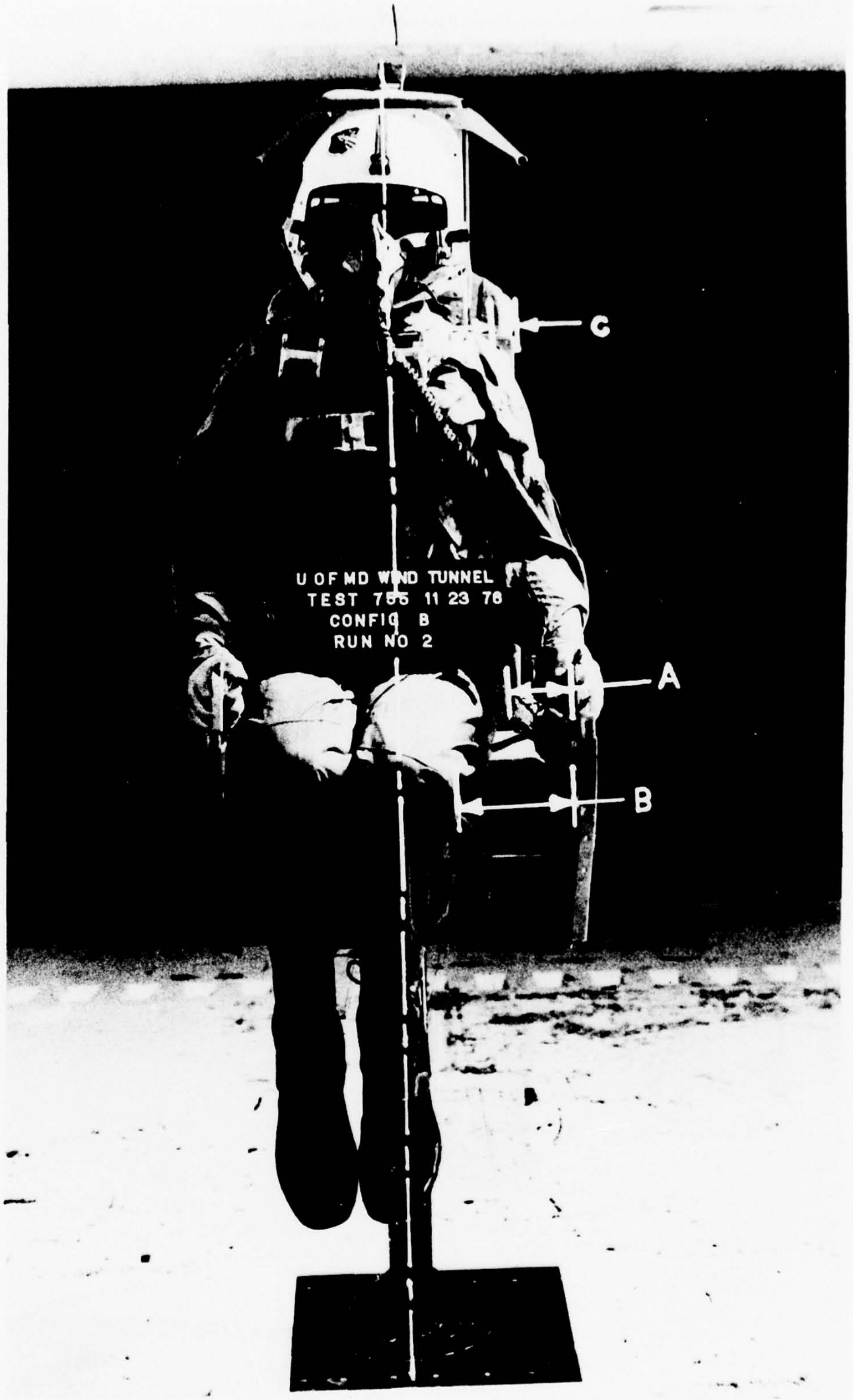

Figure 2. Anthropometric dummy in ACES II ejection seat. Configuration (B)

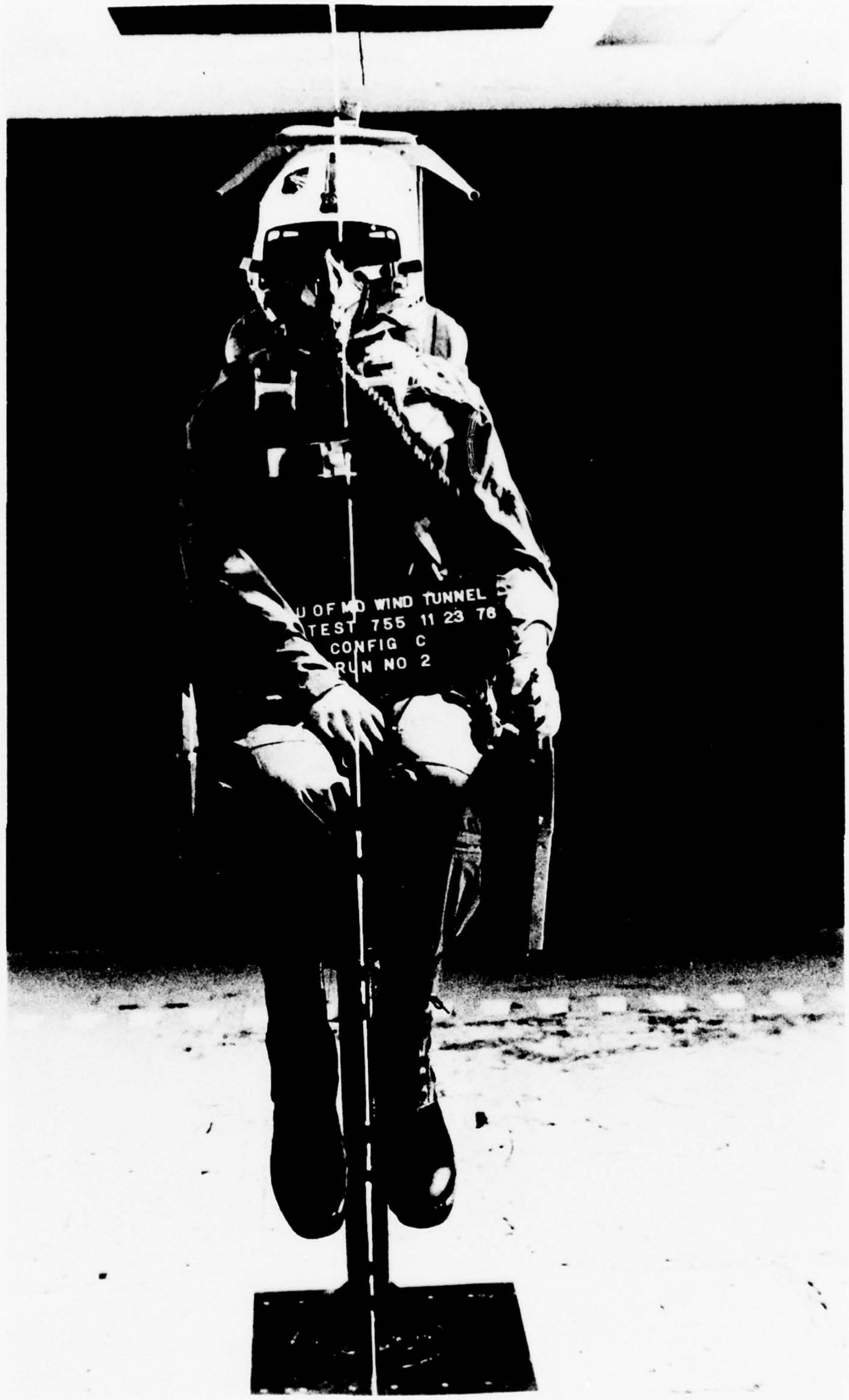

Figure 3. Anthropometric dummy in ACES II ejection seat. Configuration (C)

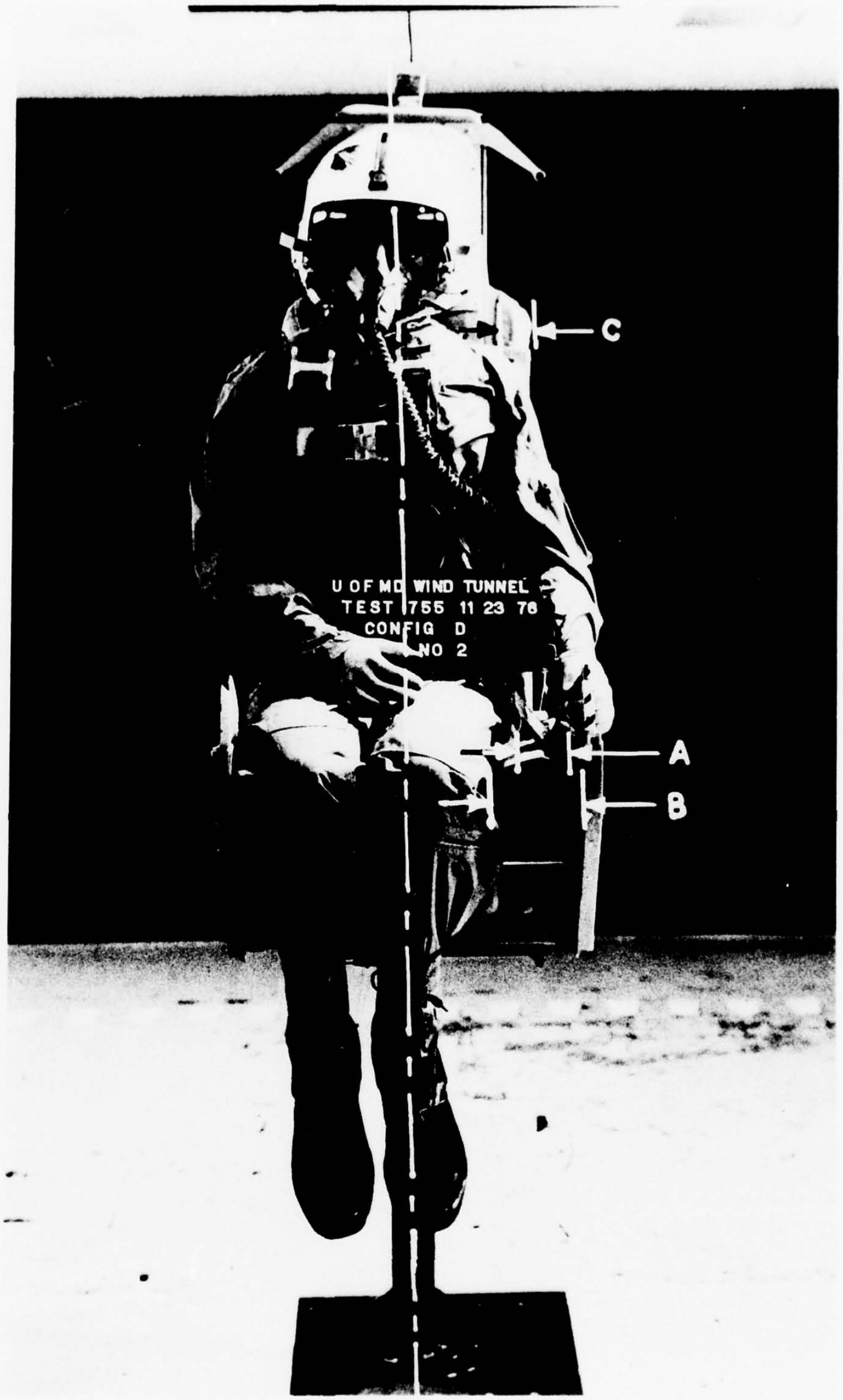

Figure 4. Anthropometric dummy in ACES II ejection seat. Configuration (D)

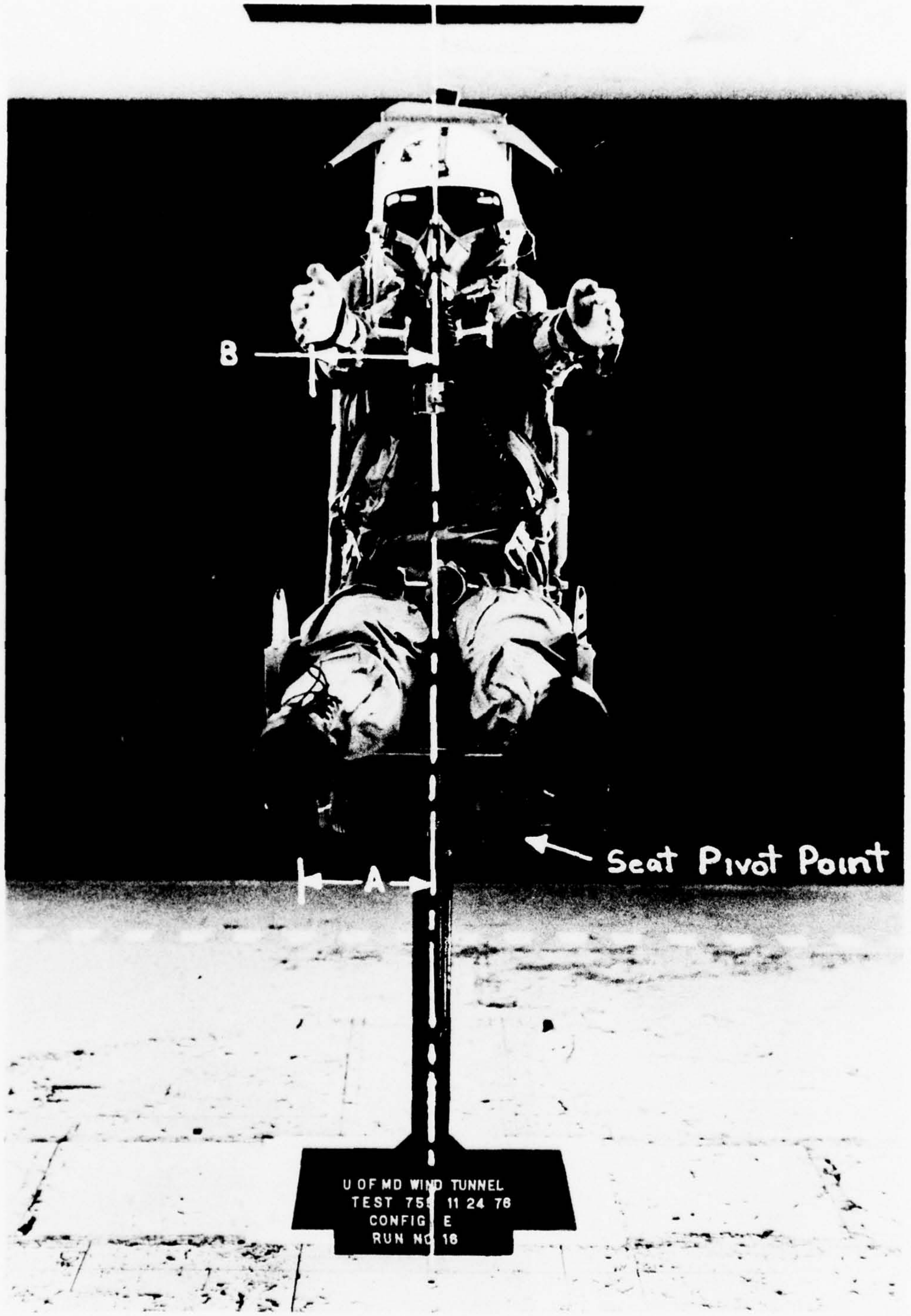

Figure 5. Anthropometric dummy in ACES II ejection seat. Configuration (E)

Figure 6. Anthropometric dummy in ACES II ejection seat. Configuration (F)

Figure 7. Anthropometric dummy in ACES II ejection seat. Configuration (G)

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Figure 8. Anthropometric dummy in ACES II ejection seat. Configuration (H)

Table 1. Wind Tunnel Test Matrix
Asymmetric Body Positions

Run No.	Angle of Attack α (Degrees)	Angle of Yaw ψ (Degrees)	Configuration
1	-	-	Stand alone tares
2 - 7	0, -30	0	C.G. measurements for Configuration A,B,C,D,F,H
8	0	-30, +30	F
9	-15	-30, +30	F
10	+30	-30, +30	F
11	0, -30	0	F C.G. measurement
12	0, -30	0	G C.G. measurement
13	0	-30, +30	G
14	-15	-30, +30	G
15	30	-30, +30	G
16	0, -30	0	E C.G. measurement
17	0	-30, +30	E
18	-15	-30, +30	E
19	30	-30, +30	E

V = 120 knots

Q = 48.85 lbs/ft^2

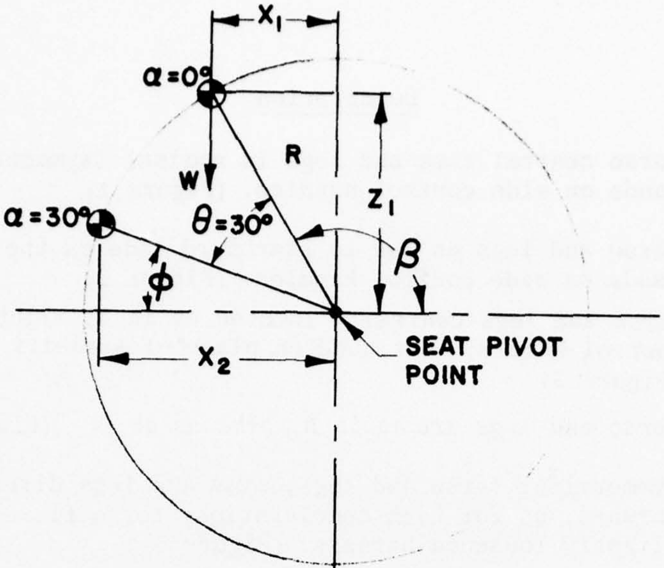
Test No. 755

November 23 - 29, 1976

Table 2. Configuration Key

Symbol	Description
A	Torso central arms and legs in nominal (symmetrical) positions; hands on side control handles. (Figure 1)
B	Torso and legs as far to starboard side as the seat side permits; hands on side control handles. (Figure 2)
C	Torso and legs centrally located as in A; right hand on side control handle; left hand on plane of symmetry of the seat. (Figure 3)
D	Torso and legs are as in B; arms as in C. (Figure 4)
E	Symmetrical torso and legs; arms and legs directly and symmetrically forward, as for high deceleration; torso flexed forward into a slightly loosened harness. (Figure 5)
F	Torso and legs symmetrical, as in A; left hand on side control; right arm straight and outboard, as far back and down as the seat structure permits. (Figure 6)
G	As for F, but with the right lower leg (calf on seat pan) as far to the right as the dummy joint permits, but not exceeding 45° to the vertical. (Figure 7)
H	Both arms and legs trailing. (Figure 8)

Center of Gravity Location



The following equations describe the determination of the center of gravity location from balance measurements. Figure 9 shows all the C.G. locations for the various configurations.

(1) $$R \cos \phi = X_2 = \frac{M_2}{W} = \frac{\text{Moment}}{\text{Weight}}$$

$$R \cos (\phi + \theta) = X_1 = \frac{M_1}{W}$$

(2) $$\frac{\cos \phi}{\cos (\phi + \theta)} = \frac{X_2}{X_1} = \frac{\cos \phi}{\cos \phi \cos \theta - \sin \phi \sin \theta}$$

(3) $$\frac{X_1}{X_2} = \cos \theta - \tan \phi \sin \theta$$

(4) $$\tan \phi = \frac{\cos \theta}{\sin \theta} - \left(\frac{1}{\sin \theta}\right) \frac{X_1}{X_2}$$

(5) $$\phi = \tan^{-1} \left(\frac{\cos \theta}{\sin \theta} - \frac{X_1}{X_2 \sin \theta}\right)$$

$R = X_2/\cos \phi$ from Equation 1

$\beta = 180° - (\theta + \phi)$

$Z = R \sin (\theta + \phi)$

Test Data

The wind tunnel test data is included in the Appendix. These data are plotted for convenience in Figures 10 - 33, relative to body axes, as shown in Figure 9.

Variation Between Configurations at $\alpha = 0°$, $\psi = 0°$

Figure 10 shows a comparison of the pitching moment volume between configurations in the zero pitch and zero yaw angle condition. Configuration E stands out as having the most significant change in initial pitching moment. This result is expected because when the legs are raised there is a decrease in the frontal area below the center of gravity. This results in a positive increase in the pitching moment. The variation in rolling moment volume between configurations A,B,C,D, and F is slight. Configurations E,G and H show a reduction in the initial rolling moment (Figure 11).

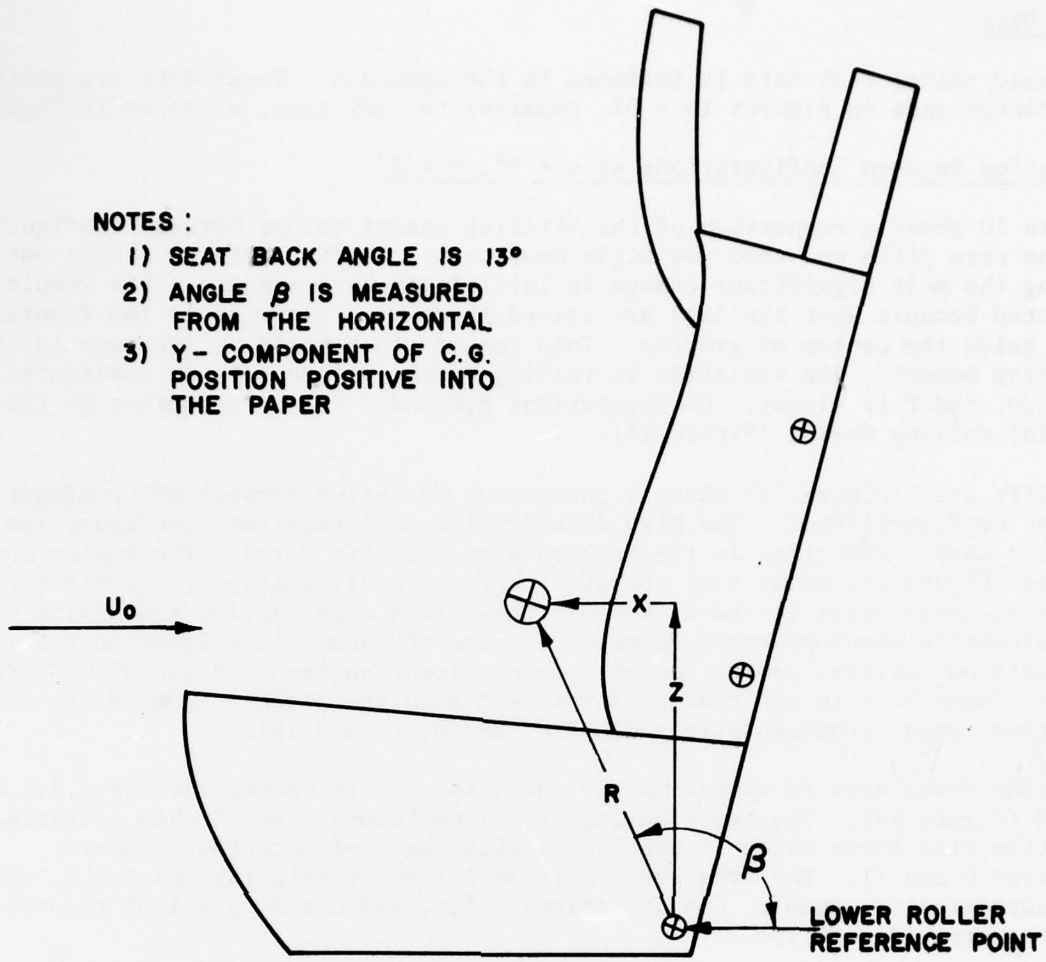
The lift area (Figure 12) shows a consistent variation between all configurations except configuration E. The high deceleration configuration (configuration E) shows a marked reduction in the magnitude of the lift force. The yawing moment volume (Figure 13) shows some variation between configurations. Configuration A has a slightly negative yawing moment (consistent with earlier tests with 5 and 95 percentile anthropometric dummies[1]). When the dummy is shifted to his right, a resulting positive yawing moment develops (configurations B and D). Shifting of the dummy back to the center of the seat results in the return of the slightly negative moment (configurations C,E,F,G, and H, Figure 13).

The side force area is approximately equal to zero in configurations A,B,C,D,E, and H (Figure 14). The two simulated flail positions F and G show a distinct negative side force which is consistent with the configuration asymmetry (Figures 6 and 7). The drag areas (Figure 15) for configurations A,B,C, and D are approximately equal. Configurations E,F,G, and H show a slight reduction in drag area (Figure 15).

Variation With Yaw Angle, Configurations E,F and G (Body Axes)

Figures 16 thru 33 show the various forces and moments as a function of yaw angle for configurations E,F and G. Configurations F and G are simulated flail configurations, and E is a simulated deceleration configuration. The variation of yawing moment with yaw angle shows an unstable static stability (Figures 17, 23 and 29) in all cases. If the seat is perturbed in a positive yaw direction, a resulting positive yawing moment will tend to drive the seat to an even greater positive yawing angle and vice versa. The seat/occupant combination will experience an unstable motion if there is no other means of stabilization (fins, vernier rockets, etc.).

The lift force area plots show similar results between configurations E,F and G (Figures 16,22 and 28). Configuration E (Figure 28) shows a greater lift force area for a given angle of attack. This would be expected due mainly to the initial orientation of the arms and legs (Figure 5).



Config.	R (feet)	β (degrees)	X (feet)	Y_1 (α = o°) (feet)	Y_2 (α = -30°) (feet)	Z (feet)
A	1.663	117.0	.755	.0197	0	1.482
B	1.649	118.2	.778	-.093	-.093	1.454
C	1.650	117.7	.766	-.0059	0	1.461
D	1.661	118.0	.779	-.079	-.089	1.467
E	1.866	117.3	.964	.0296	.0316	1.598
F	1.644	114.3	.743	.0040	.0032	1.467
G	1.674	114.0	.746	0.0	.0179	1.498
H	1.636	115.4	.702	.0079	-.0099	1.478

Figure 9. CG locations for various configurations of the ACES II ejection seat and anthropometric dummy.

The pitching moment volume plots are given in Figures 18, 24 and 30. Configurations F and G (Figures 18 and 24) show very similar variations. Configuration E (Figure 30) shows a substantial positive pitching moment volume.

The pitching moment volume plots (Figures 18,24 and 30) have little value when plotted against yaw angle except to show gross comparison. Configurations F and G (Figures 18 and 24) show very similar variations. Configuration E (Figure 30) shows a substantial positive pitching moment volume. This is due primarily to the substantial positive lift forces generated in this configuration.

The comparison of rolling moment with yaw angle is seen in Figures 19, 25 and 31. Configurations F and G (Figures 19 and 25) show similar rolling moment variation. A positive yaw angle results in a negative rolling moment and vice versa. Configuration E (Figure 31) shows a substantial shift of the rolling moment in the negative direction for negative yaw angle and the positive direction for positive yaw angle.

The side force area shows the expected increase with yaw angle (Figures 20,26 and 32). Both configurations F and G show a distinct negative side force at 0° yaw. This is consistent with the limb asymmetries. (Figures 6 and 7). Configuration E generally shows a greater side force at a given yaw angle. The drag areas are also similar between configurations E,F and G (Figures 21,27 and 33). The pitch angle of 30° results in a decreased drag area in all cases.

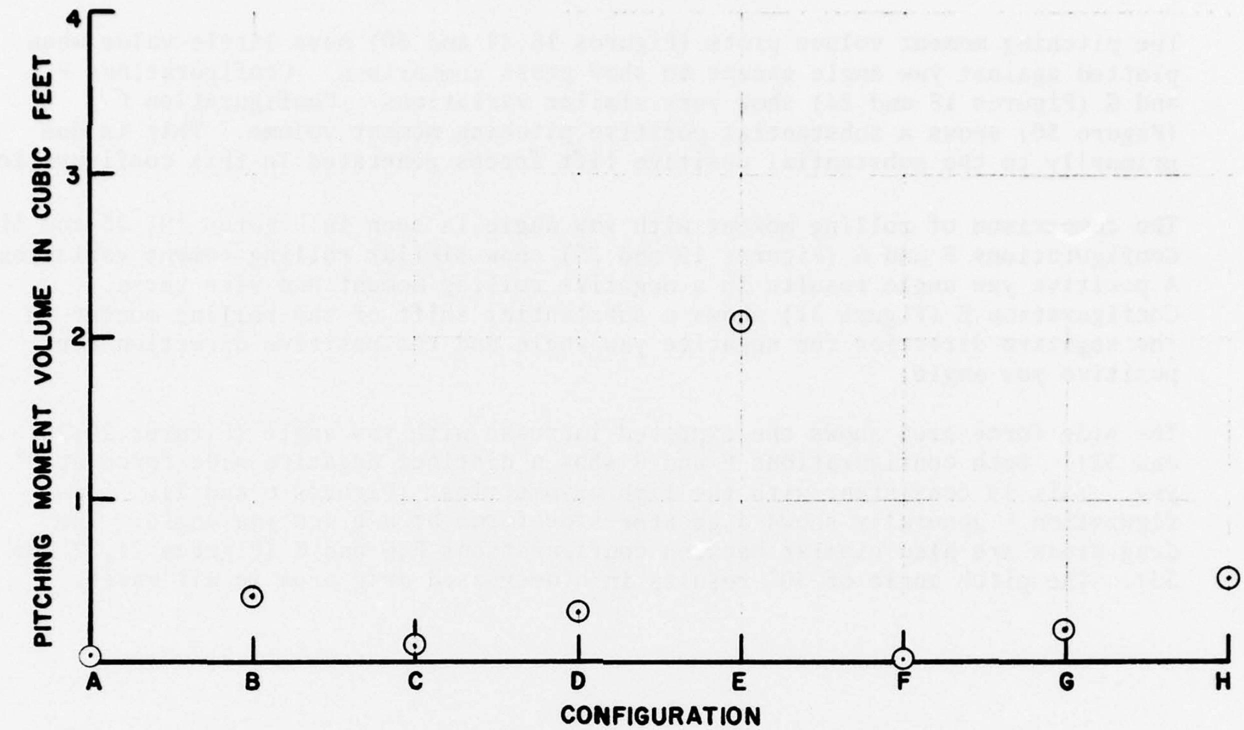


Figure 10. Comparison of pitching moment volume with configuration ($\alpha = 0°$, $\psi = 0°$) *for the ACES II ejection seat with anthropometric dummy.*

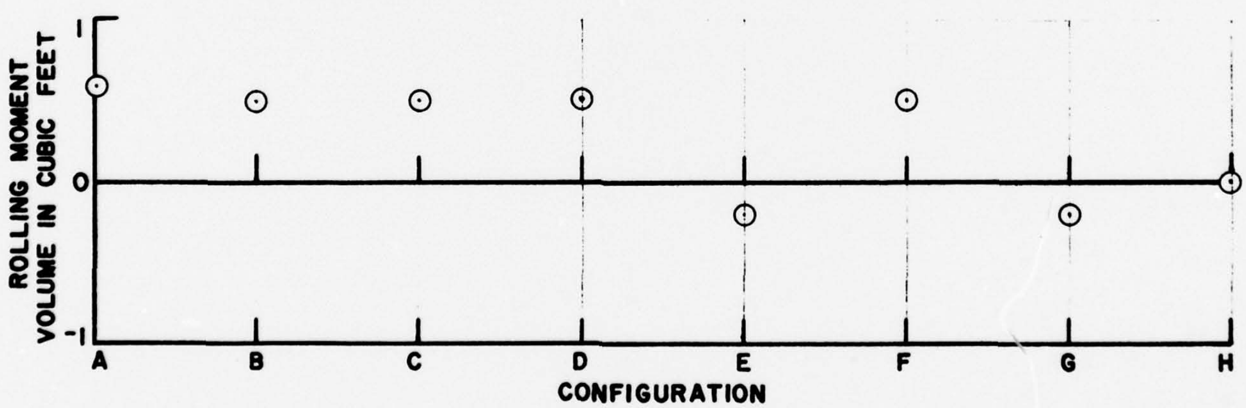


Figure 11. Comparison of rolling moment volume with configuration ($\alpha = 0°$, $\psi = 0°$) for the ACES II ejection seat with anthropometric dummy.

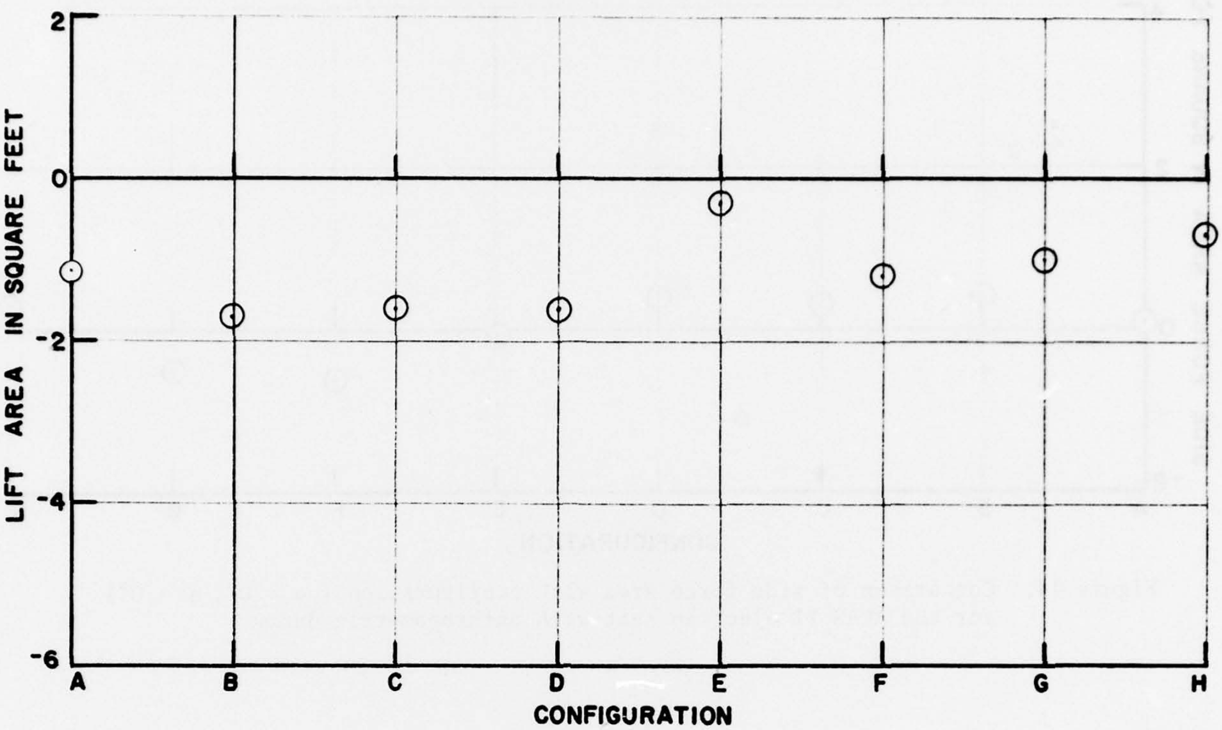


Figure 12. Comparison of lift area with configuration ($\alpha = 0°$, $\psi = 0°$) for the ACES II ejection seat with anthropometric dummy.

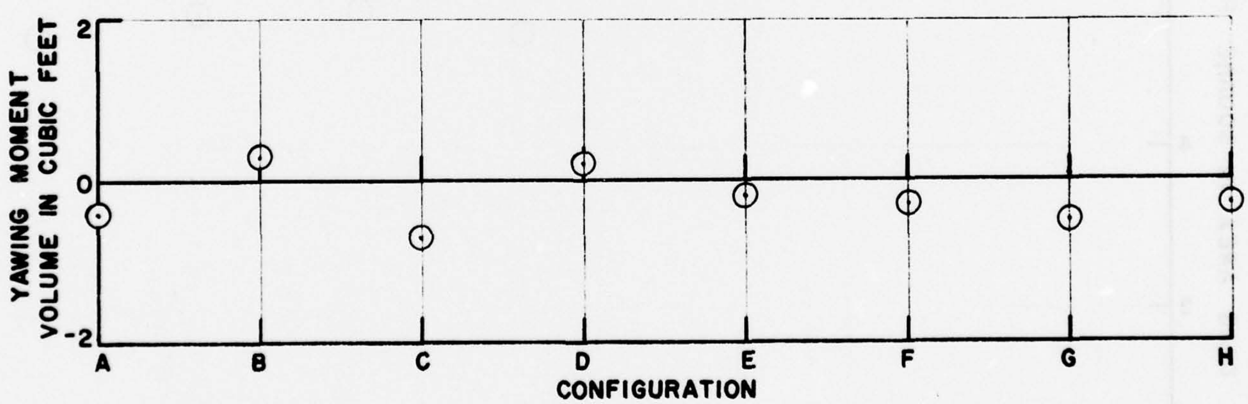


Figure 13. Comparison of yawing moment volume with configuration ($\alpha = 0°$, $\psi = 0°$) for the ACES II ejection seat with anthropometric dummy.

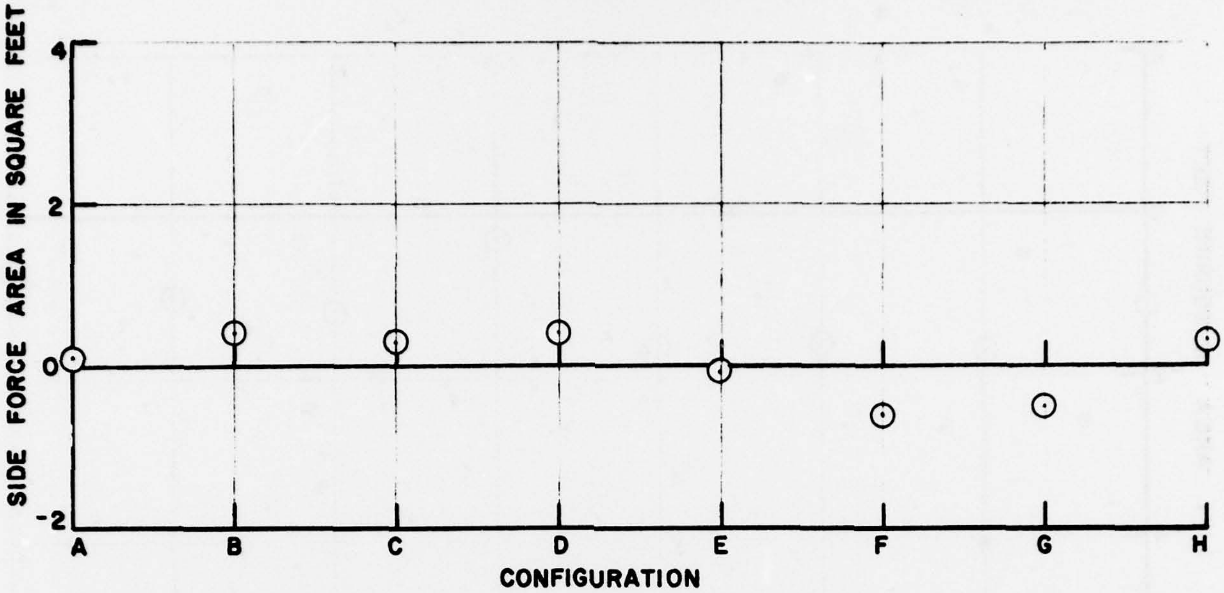


Figure 14. Comparison of side force area with configuration ($\alpha = 0°$, $\psi = 0°$) for the ACES II ejection seat with anthropometric dummy.

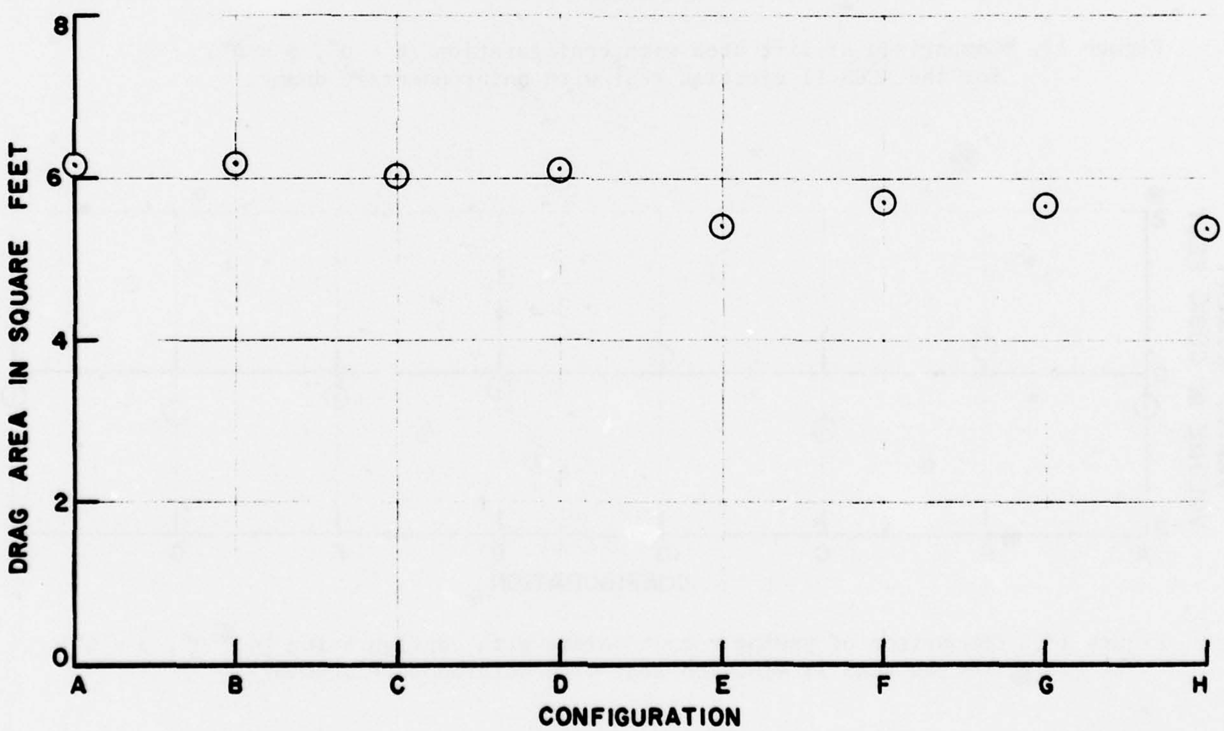


Figure 15. Comparison of drag force area with configuration ($\alpha = 0°$, $\psi = 0°$) for the ACES II ejection seat with anthropometric dummy.

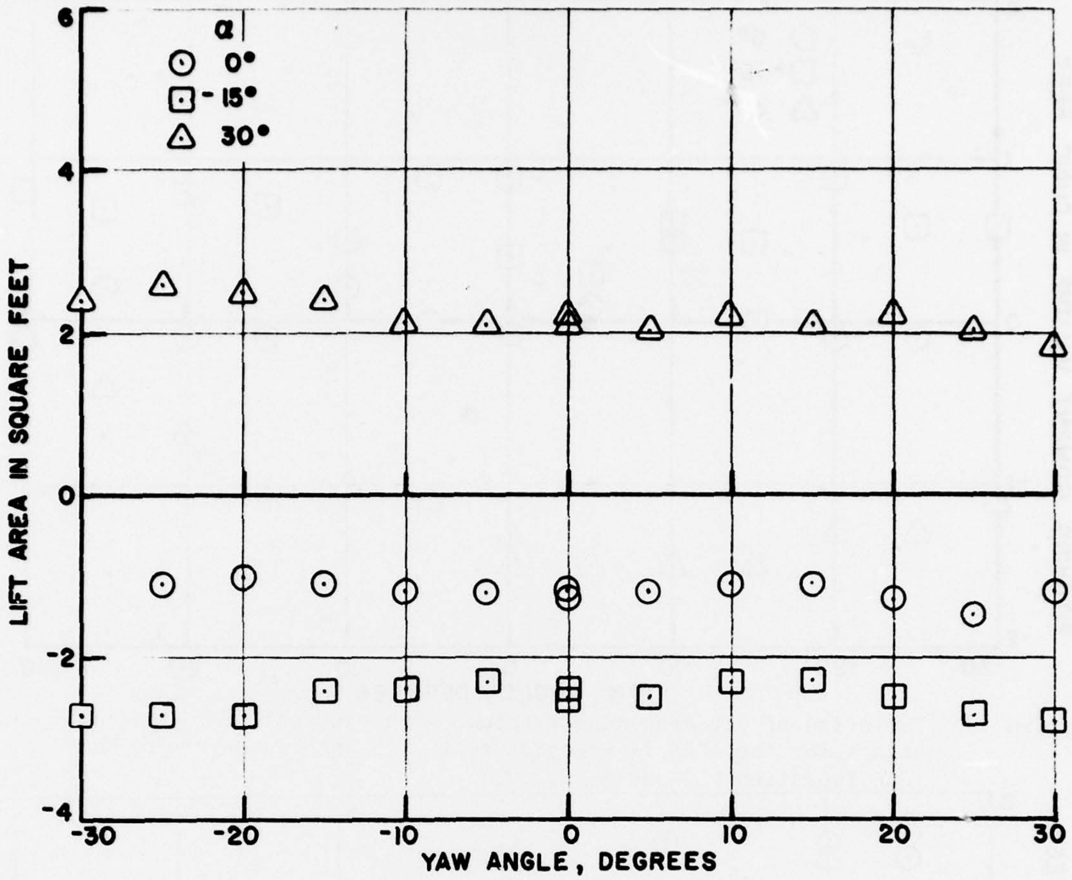


Figure 16. Variation of lift area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration F, Runs 8, 9, 10)

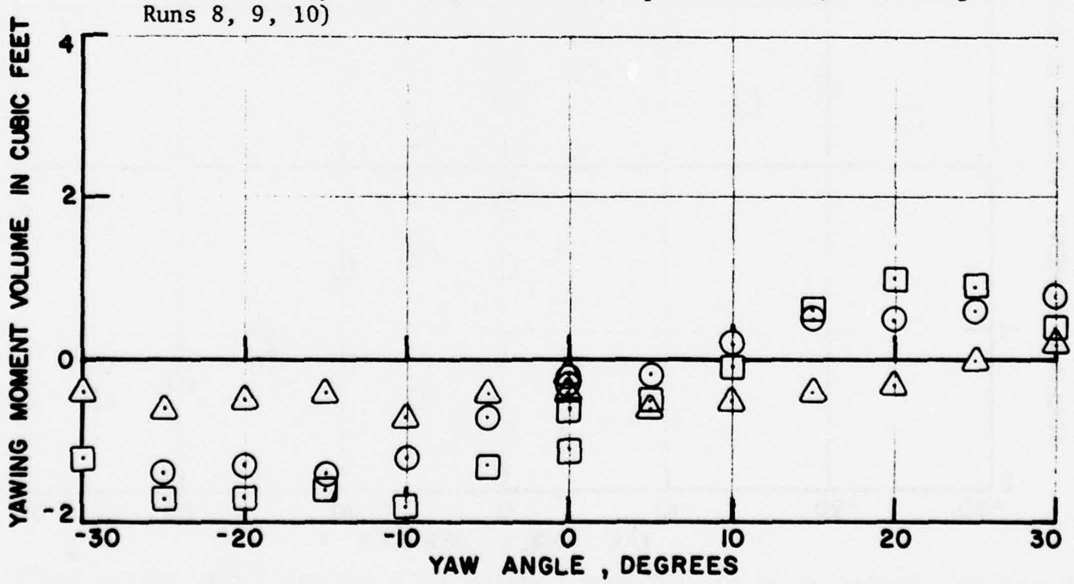


Figure 17. Variation of yawing moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration F, Runs 8, 9, 10)

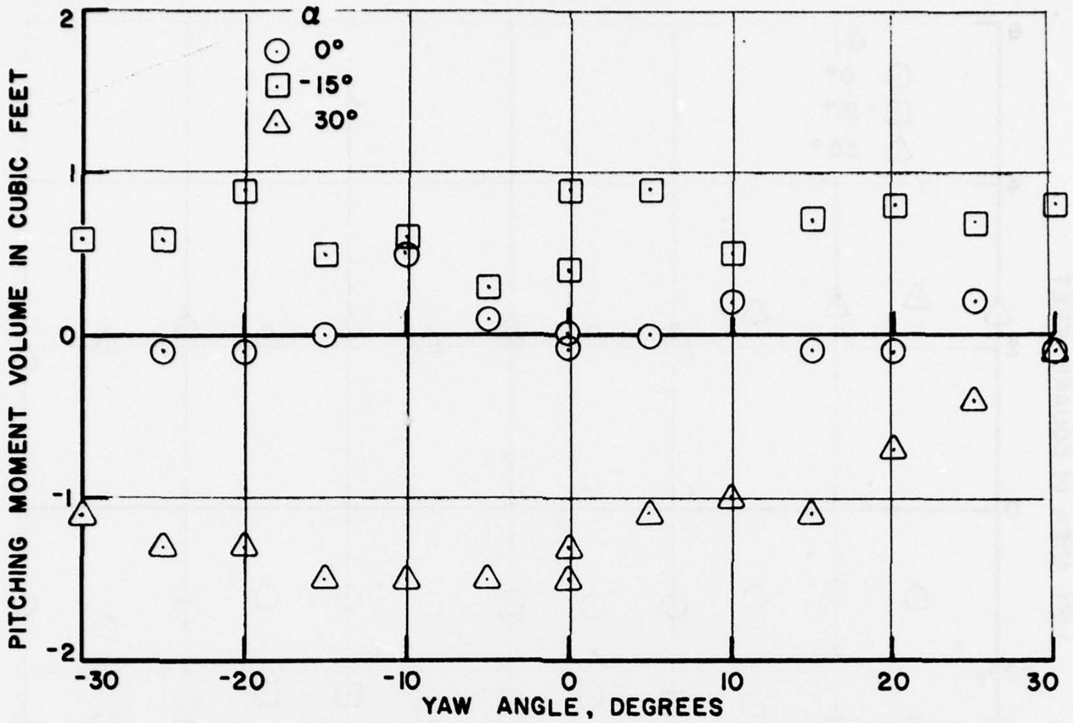


Figure 18. Variation of pitching moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration F, Runs 8, 9, 10)

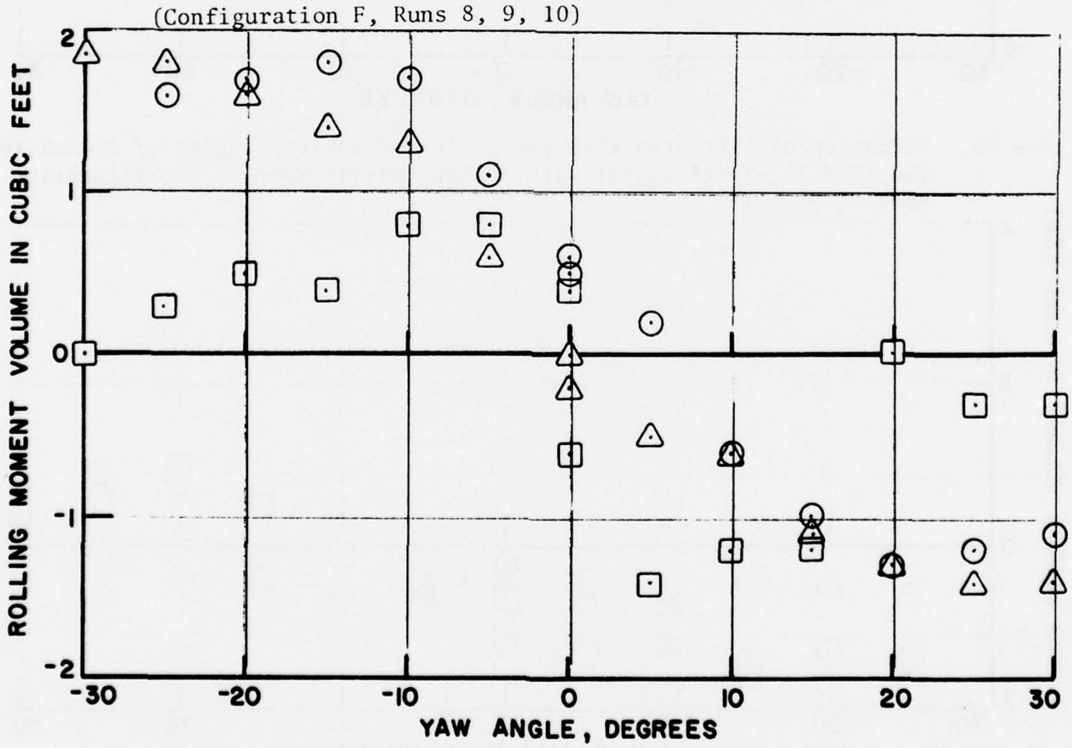


Figure 19. Variation of rolling moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration F, Runs 8, 9, 10)

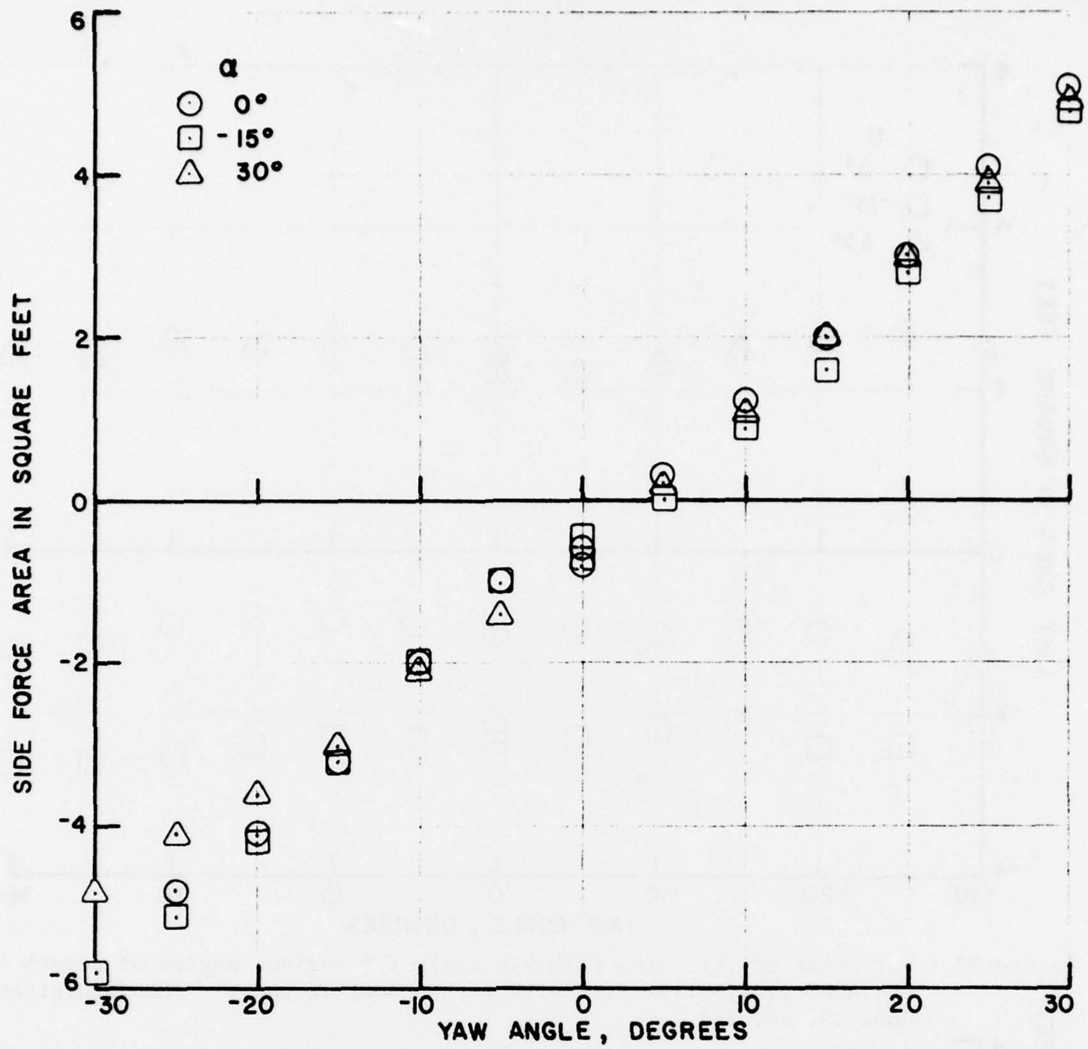


Figure 20. Variation of side force area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration F, Runs 8, 9, 10)

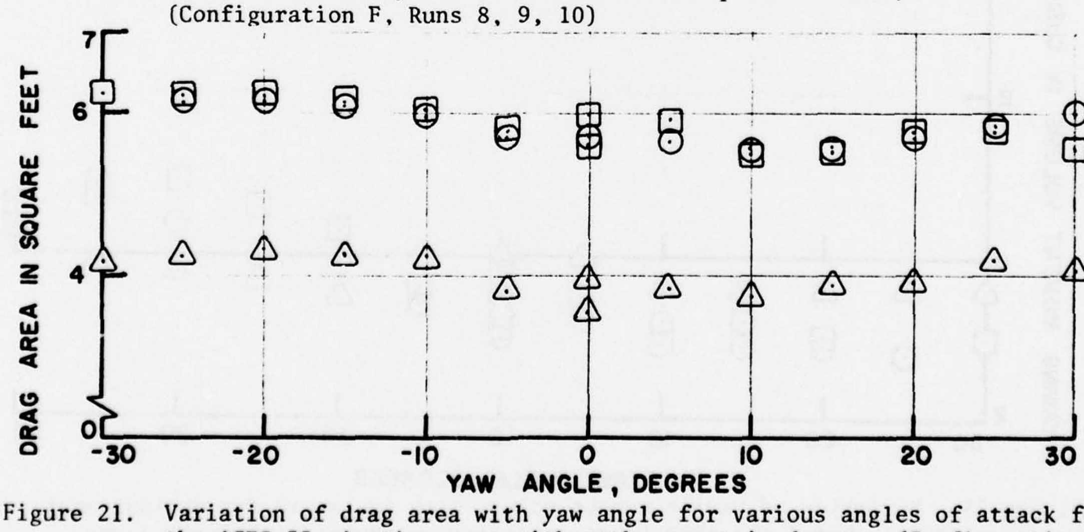


Figure 21. Variation of drag area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration F, Runs 8, 9, 10)

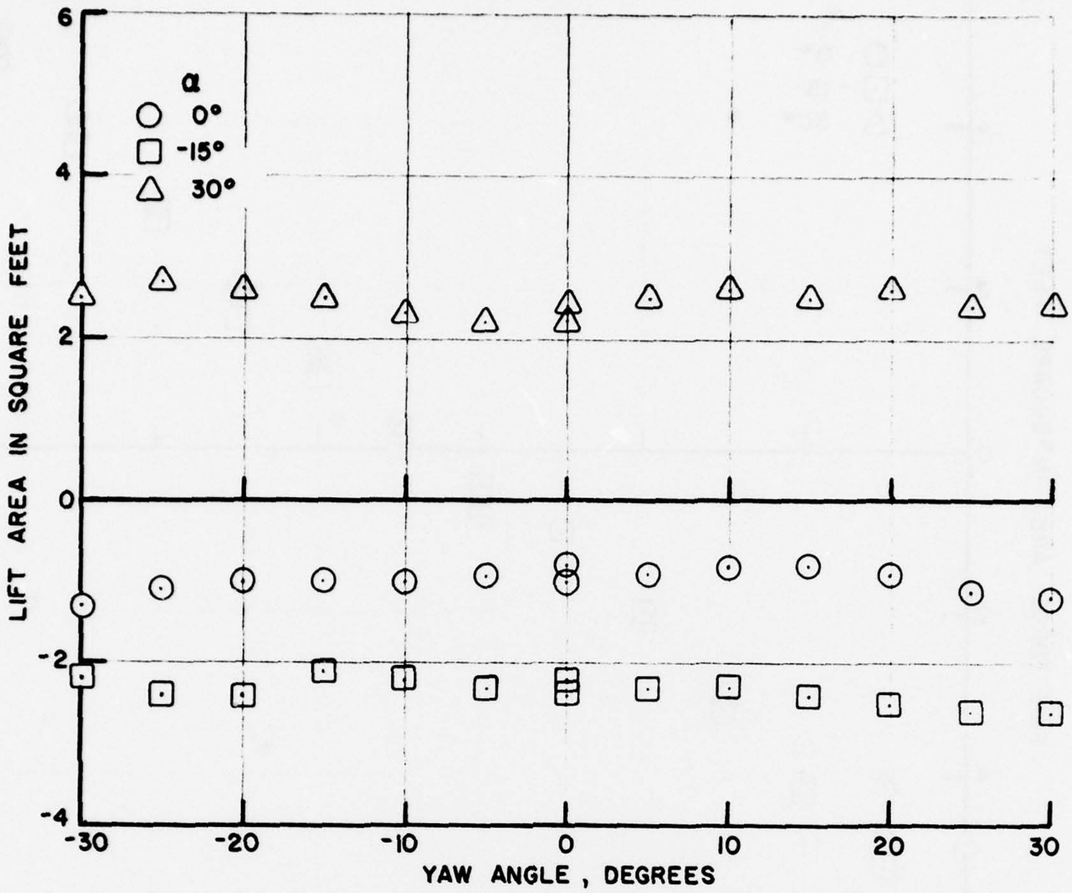


Figure 22. Variation of lift area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration G, Runs 13, 14, 15)

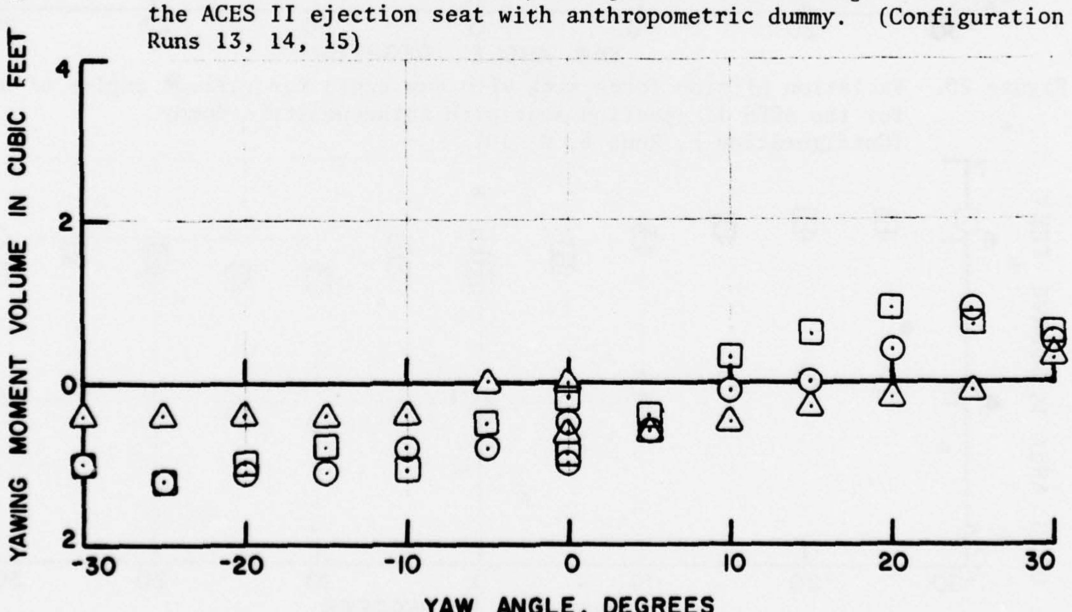


Figure 23. Variation of yawing moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration G, Runs 13, 14, 15)

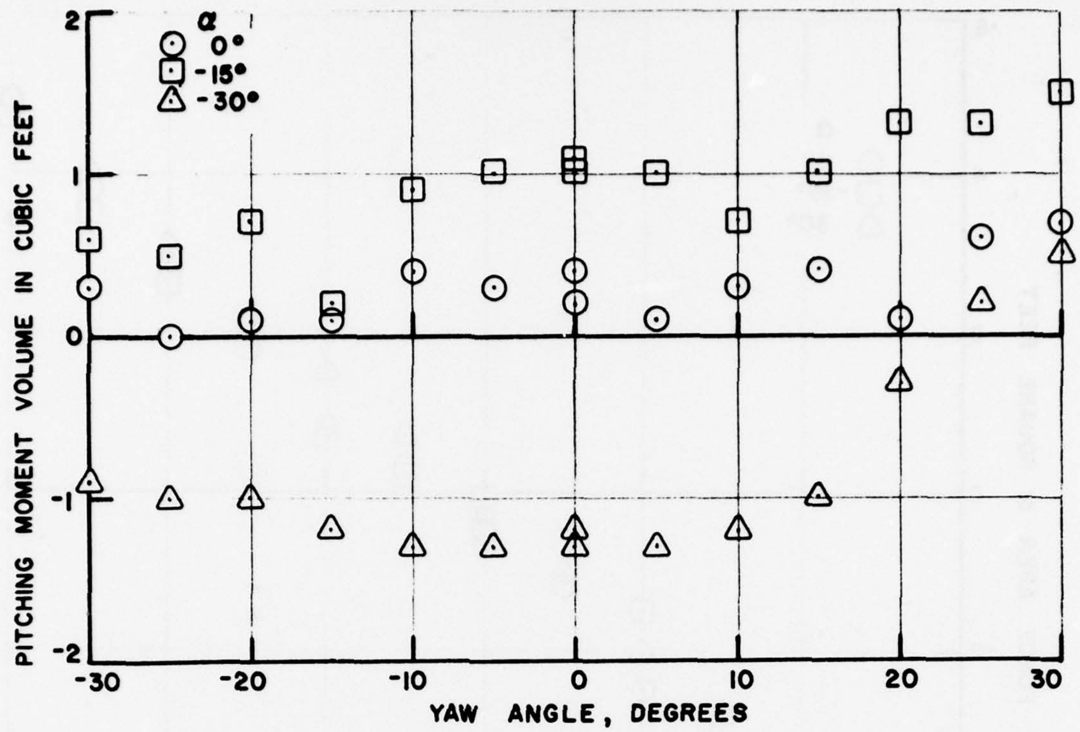


Figure 24. Variation of pitching moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration G, Runs 13, 14, 15)

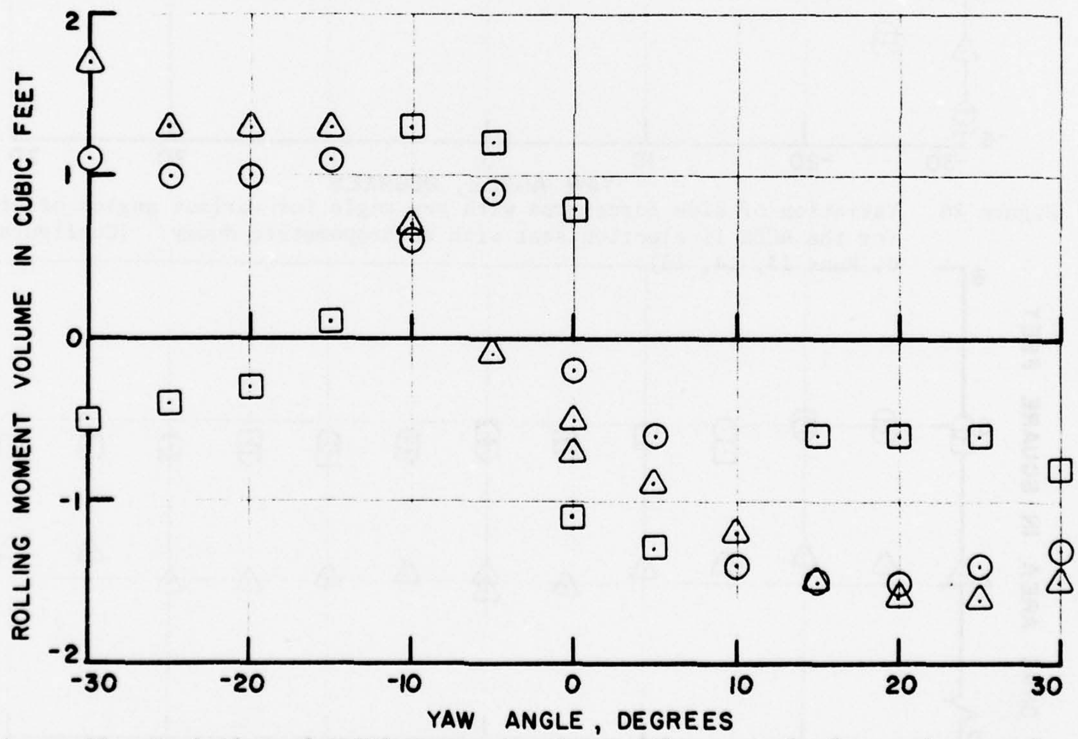


Figure 25. Variation of rolling moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration G, Runs 13, 14, 15)

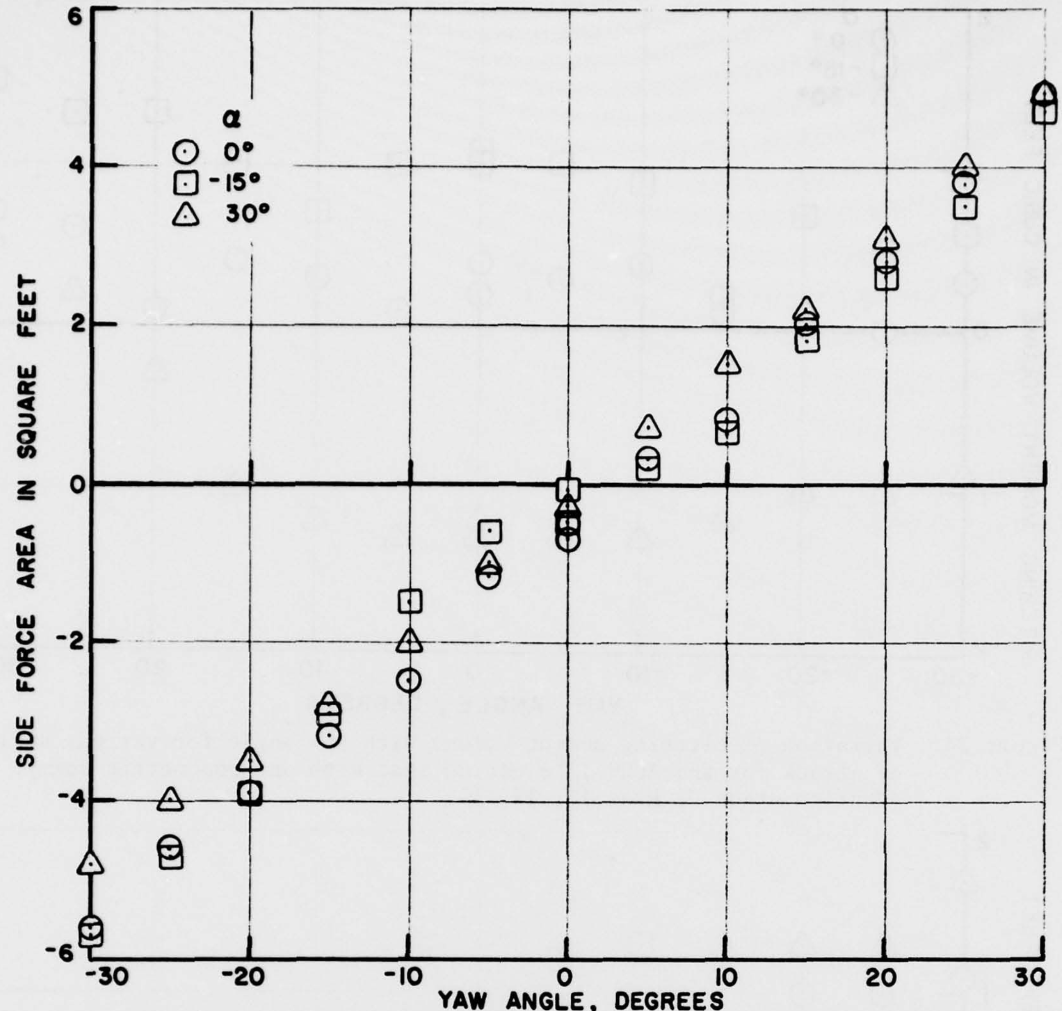


Figure 26. Variation of side force area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration G, Runs 13, 14, 15)

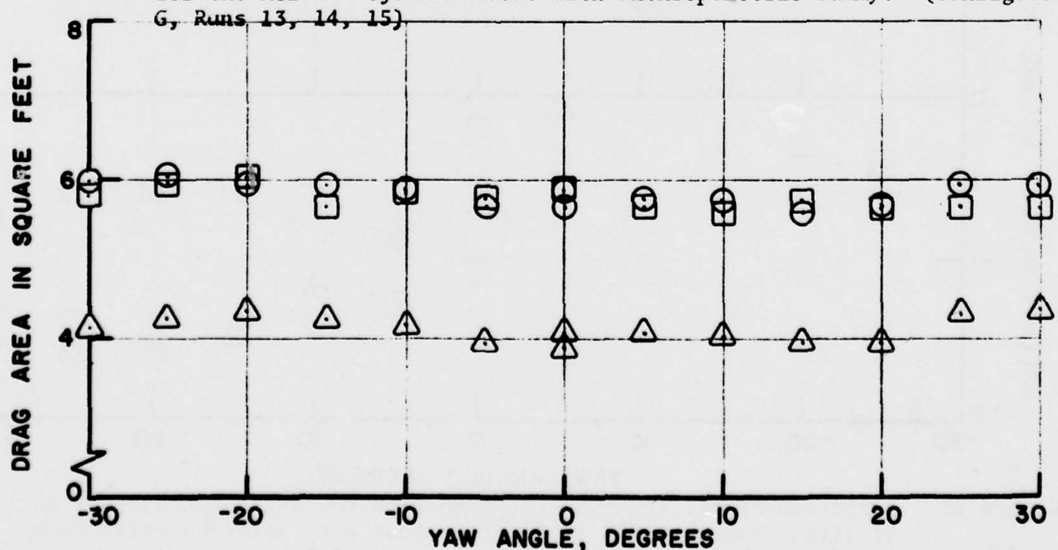


Figure 27. Variation of drag force area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration G, Runs 13, 14, 15)

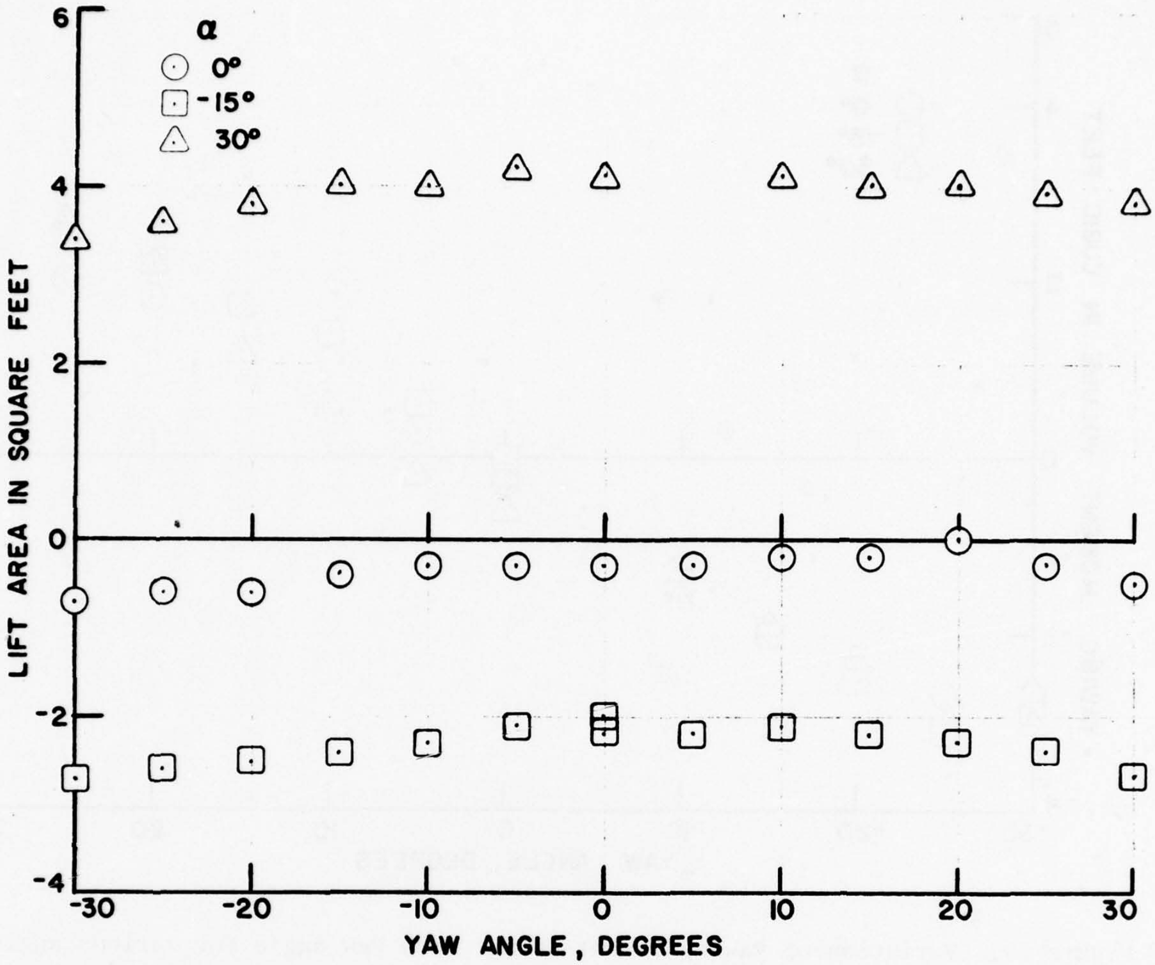


Figure 28. Variation of lift area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration E, Runs 17, 18, 19)

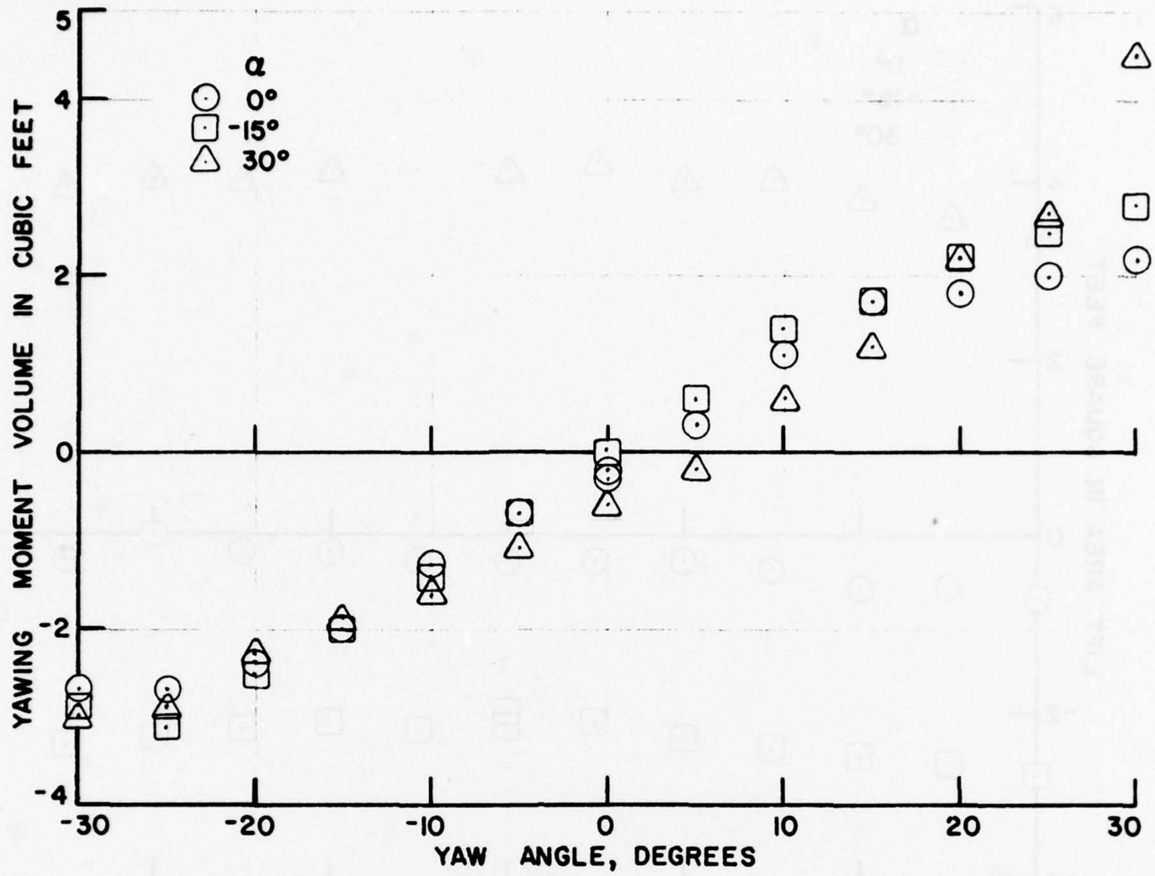


Figure 29. Variation of yawing moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration E, Runs 17, 18, 19)

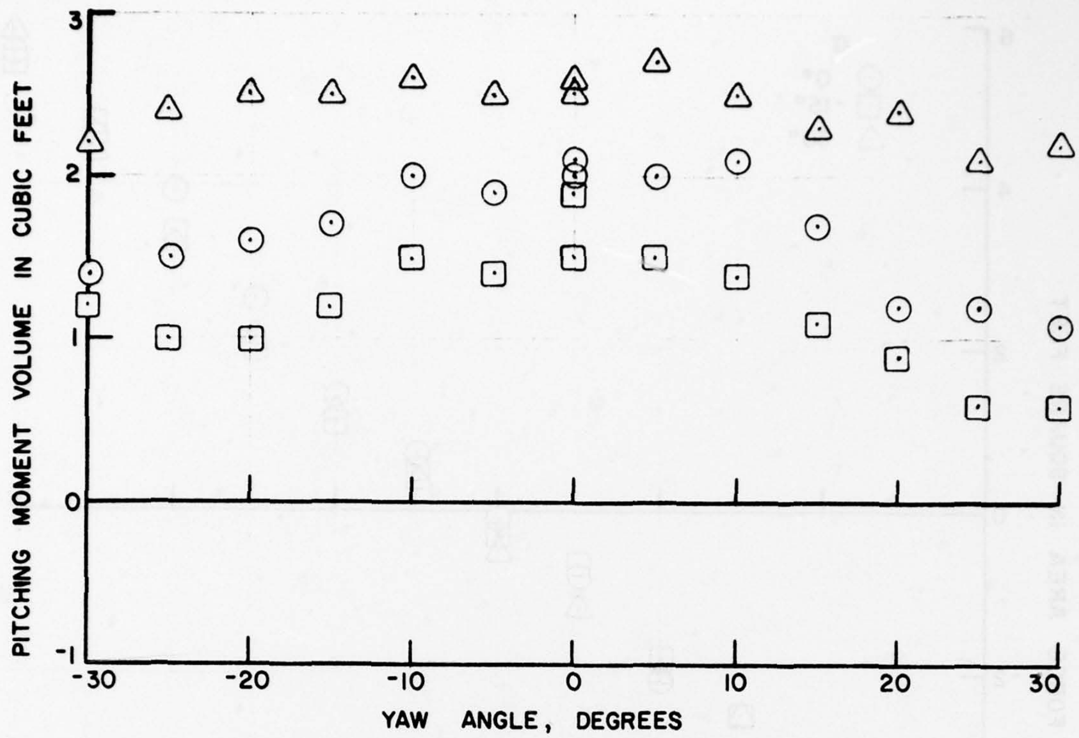


Figure 30. Variation of pitching moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration E, Runs 17, 18, 19)

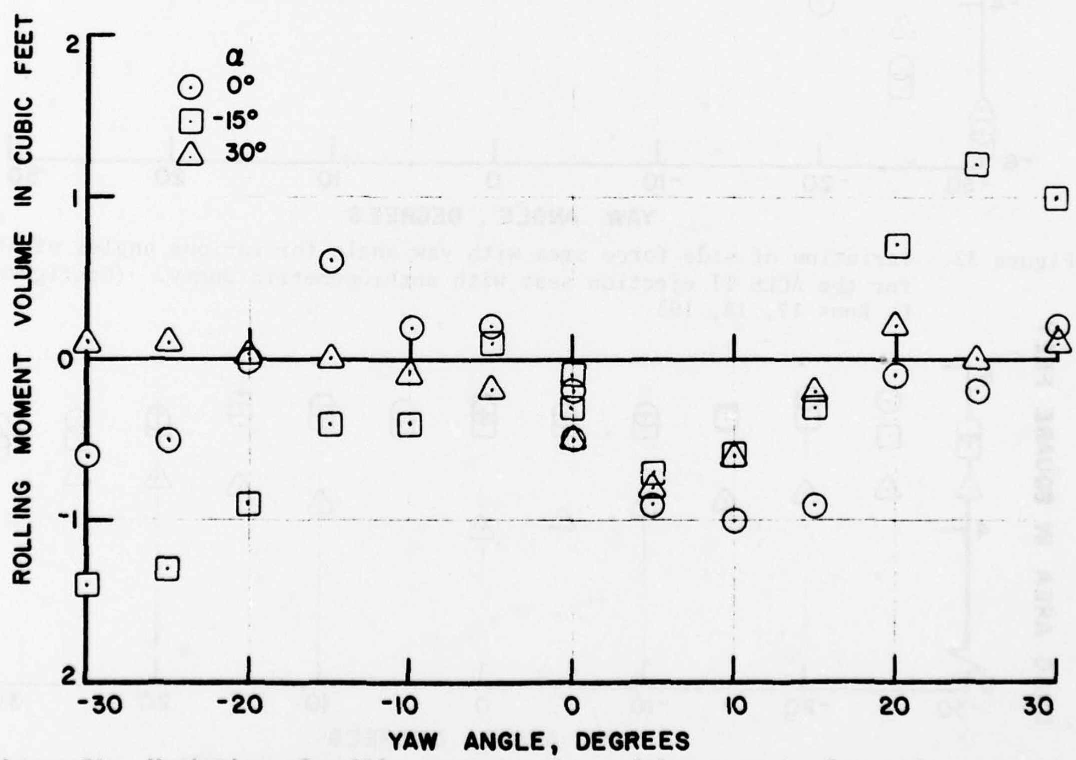


Figure 31. Variation of rolling moment volume with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration E, Runs 17, 18, 19)

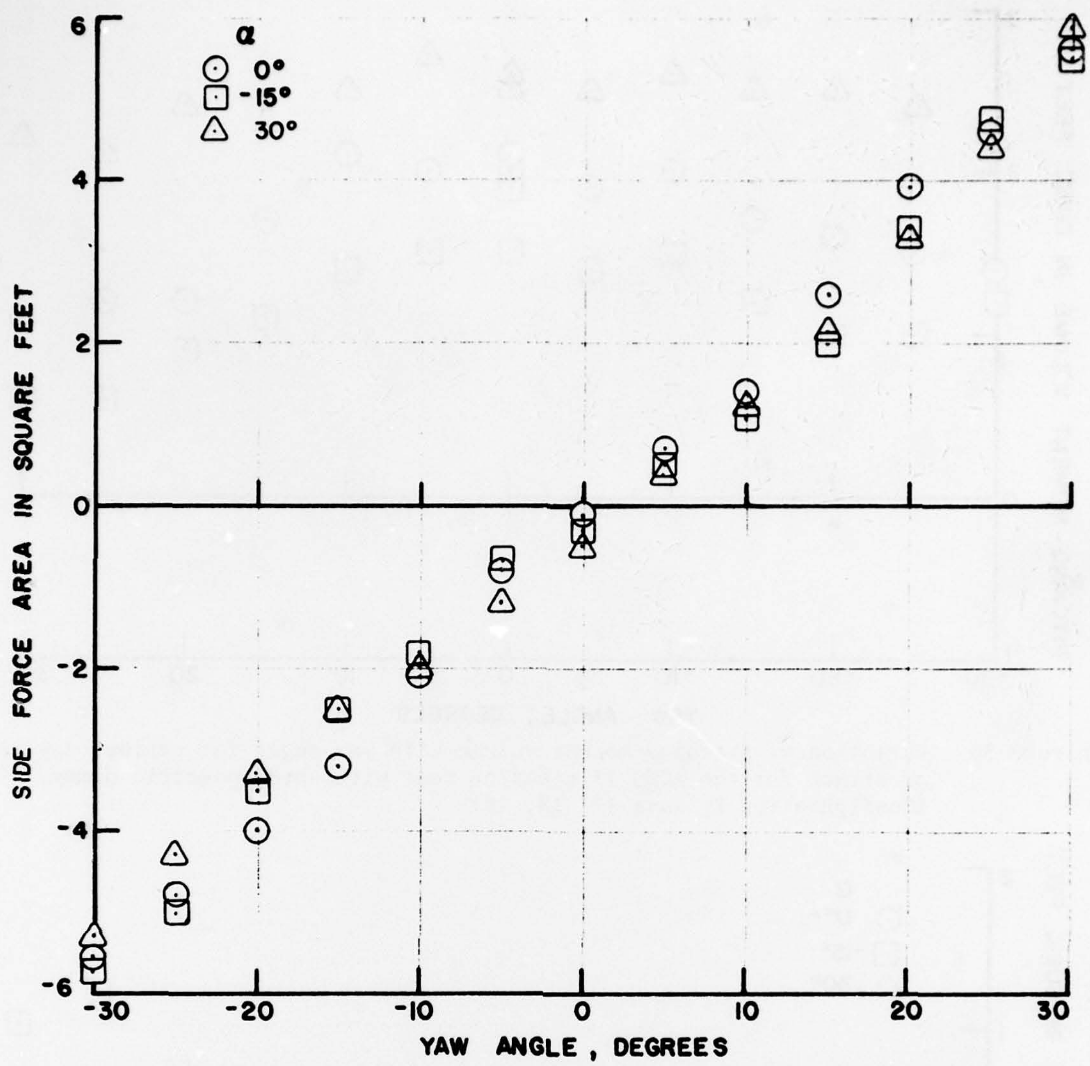


Figure 32. Variation of side force area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration E, Runs 17, 18, 19)

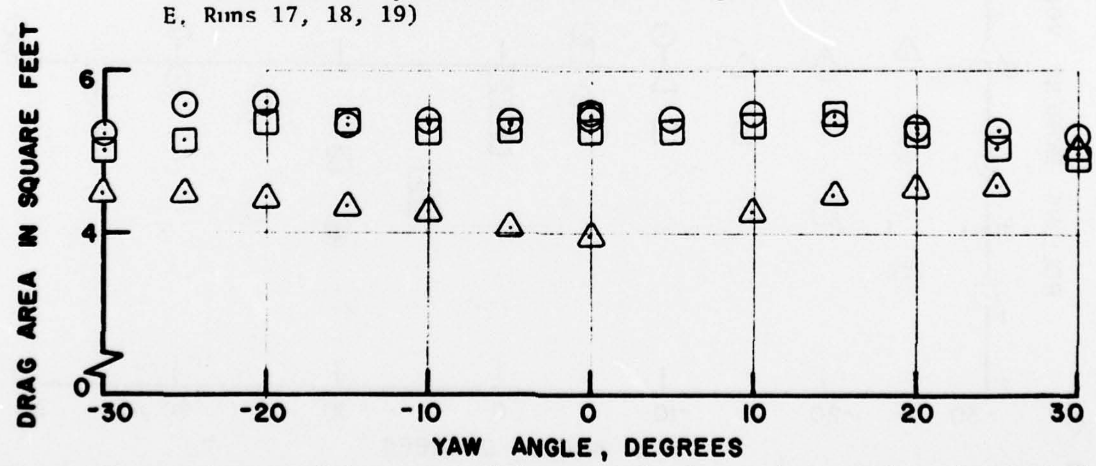


Figure 33. Variation of drag area with yaw angle for various angles of attack for the ACES II ejection seat with anthropometric dummy. (Configuration E, Runs 17, 18, 19)

APPENDIX

ACES II Ejection Seat With 50 Percentile
Anthropometric Dummy Wind Tunnel Test Data
(Body Axes)

LIST OF SYMBOLS

AA	=	Angle of attack (α) - degrees.
AY	=	Angle of Yaw (ψ) - degrees.
L	=	Lift force area - square feet.
D	=	Drag force area - square feet.
PM	=	Pitching moment volume - cubic feet.
YM	=	Yawing moment volume - cubic feet.
RM	=	Rolling moment volume - cubic feet.
SF	=	Side force area - square feet.

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 3							
0.0	0.0	-0.7	5.39	0.5	-0.3	0.0	0.3
RUN NO. 4							
0.0	0.0	-1.1	6.31	.05	-0.4	0.6	0.1
RUN NO. 5							
0.0	0.0	-1.6	6.02	0.1	-0.7	0.5	0.3
RUN NO. 6							
0.0	0.0	-1.6	6.10	0.3	0.2	0.5	0.4
RUN NO. 7							
0.0	0.0	-1.7	6.19	0.4	0.3	0.5	0.4

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 8							
0.0	-0.0	-1.2	5.70	0.0	-0.3	0.5	-0.6
-0.0	-5.0	-1.2	5.70	0.1	-0.7	1.1	-1.0
-0.0	-10.0	-1.2	5.98	0.5	-1.2	1.7	-2.0
-0.0	-15.0	-1.1	6.10	0.0	-1.4	1.8	-3.2
-0.0	-20.0	-1.0	6.16	-0.1	-1.3	1.7	-4.1
-0.0	-25.0	-1.1	6.14	-0.1	-1.4	1.6	-4.8
-0.0	0.0	-1.3	5.71	-0.1	-0.2	0.6	-0.8
0.0	5.0	-1.2	5.66	0.0	-0.2	0.2	0.3
0.0	10.0	-1.1	5.58	0.2	0.2	-0.6	1.2
0.0	15.0	-1.1	5.59	-0.1	0.5	-1.0	2.0
0.0	20.0	-1.3	5.70	-0.1	0.5	-1.3	3.0
0.0	25.0	-1.5	5.84	0.2	0.6	-1.2	4.1
0.0	30.0	-1.2	6.0	-0.1	0.8	-1.1	5.1

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 9							
-15.0	-0.0	-2.4	5.6	0.4	-0.6	0.4	-0.5
-15.0	-5.0	-2.3	5.75	0.3	-1.3	0.8	-1.0
-15.0	-10.0	-2.4	6.02	0.6	-1.8	0.8	-2.0
-15.0	-15.0	-2.4	6.13	0.5	-1.6	0.4	-3.2
-15.0	-20.0	-2.7	6.22	0.9	-1.7	0.5	-4.2
-15.0	-25.0	-2.7	6.24	0.6	-1.7	0.3	-5.1
-15.0	-30.0	-2.7	6.25	0.6	-1.2	0.0	-5.8
-15.0	0.0	-2.5	5.99	0.9	-1.1	-0.6	-0.7
-15.0	5.0	-2.5	5.91	0.9	-0.5	-1.4	0.0
-15.0	10.0	-2.3	5.51	0.5	-0.1	-1.2	0.9
-15.0	15.0	-2.3	5.51	0.7	0.6	-1.2	1.6
-15.0	20.0	-2.5	5.73	0.8	1.0	0.0	2.8
-15.0	25.0	-2.7	5.79	0.7	0.9	-0.3	3.7
-15.0	30.0	-2.8	5.57	0.8	0.4	-0.3	4.8

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 10							
30.0	-0.0	2.1	3.56	-1.3	-0.3	-0.2	-0.7
30.0	-5.0	2.1	3.81	-1.5	-0.4	0.6	-1.4
30.0	-10.0	2.1	4.23	-1.5	-0.7	1.3	-2.1
30.0	-15.0	2.4	4.28	-1.5	-0.4	1.4	-3.0
30.0	-20.0	2.5	4.33	-1.3	-0.5	1.6	-3.6
30.0	-25.0	2.6	4.23	-1.3	-0.6	1.8	-4.1
30.0	-30.0	2.4	4.19	-1.1	-0.4	1.8	-4.8
30.0	0.0	2.2	3.93	-1.5	-0.4	0.0	-0.7
30.0	5.0	2.0	3.84	-1.1	-0.6	-0.5	0.2
30.0	10.0	2.2	3.75	-1.0	-0.5	-0.6	1.1
30.0	15.0	2.1	3.88	-1.1	-0.4	-1.1	2.0
30.0	20.0	2.2	3.92	-0.7	-0.3	-1.3	3.0
30.0	25.0	2.0	4.20	-0.4	0.0	-1.4	3.9
30.0	30.0	1.8	4.09	-0.1	0.2	-1.4	4.9

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 13							
0.0	0.0	-1.0	5.63	0.2	-0.5	-0.2	-0.5
0.0	-5.0	-0.9	5.68	0.3	-0.8	0.9	-1.2
0.0	-10.0	-1.0	5.89	0.4	-0.8	0.6	-2.5
0.0	-15.0	-1.0	5.92	0.1	-1.1	1.1	-3.2
0.0	-20.0	-1.0	5.95	0.1	-1.1	1.0	-3.9
0.0	-25.0	-1.1	6.05	0.0	-1.2	1.0	-4.6
0.0	-30.0	-1.3	5.97	0.3	-1.0	1.1	-5.6
0.0	0.0	-0.8	5.86	0.4	-1.0	-0.2	-0.7
0.0	5.0	-0.9	5.76	0.1	-0.6	-0.6	0.3
0.0	10.0	-0.8	5.72	0.3	-0.1	-1.4	0.8
0.0	15.0	-0.8	5.58	0.4	0.0	-1.5	2.0
0.0	20.0	-0.9	5.69	0.1	0.4	-1.5	2.8
0.0	25.0	-1.1	5.92	0.6	0.9	-1.4	3.8
0.0	30.0	-1.2	5.91	0.7	0.5	-1.3	4.9

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 14							
-15.0	0.0	-2.4	5.73	1.1	-0.2	0.8	-0.1
-15.0	-5.0	-2.3	5.78	1.0	-0.5	1.2	-0.6
-15.0	-10.0	-2.2	5.83	0.9	-1.1	1.3	-1.5
-15.0	-15.0	-2.1	5.68	0.2	-0.8	0.1	-2.9
-15.0	-20.0	-2.4	6.02	0.7	-1.0	-0.3	-3.9
-15.0	-25.0	-2.4	5.94	0.5	-1.2	-0.4	-4.7
-15.0	-30.0	-2.2	5.83	0.6	-1.0	-0.5	-5.7
-15.0	0.0	-2.2	5.88	1.0	-0.9	-1.1	-0.5
-15.0	5.0	-2.3	5.66	1.0	-0.4	-1.3	0.2
-15.0	10.0	-2.3	5.57	0.7	0.3	-1.4	0.6
-15.0	15.0	-2.4	5.72	1.0	0.6	-0.6	1.8
-15.0	20.0	-2.5	5.65	1.3	0.9	-0.6	2.6
-15.0	25.0	-2.6	5.67	1.3	0.7	-0.6	3.5
-15.0	30.0	-2.6	5.64	1.5	0.6	-0.8	4.7

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 15							
30.0	-0.0	2.2	3.87	-1.2	0.0	-0.7	-0.3
30.0	-5.0	2,2	3.95	-1.3	0.0	-0.1	-1.0
30.0	-10.0	2.3	4.18	-1.3	-0.4	0.7	-2.0
30.0	-15.0	2.5	4.26	-1.2	-0.4	1.3	-2.8
30.0	-20.0	2.6	4.35	-1.0	-0.4	1.3	-3.5
30.0	-25.0	2.7	4.26	-1.0	-0.4	1.3	-4.0
30.0	-30.0	2.5	4.15	-0.9	-0.4	1.7	-4.8
30.0	0.0	2.4	4.07	-1.3	-0.6	-0.5	-0.4
30.0	5.0	2.5	4.08	-1.3	-0.6	-0.9	0.7
30.0	10.0	2.6	4.01	-1.2	-0.5	-1.2	1.5
30.0	15.0	2.5	3.95	-1.0	-0.3	-1.5	2.2
30.0	20.0	2.6	3.94	-0.3	-0.2	-1.6	3.1
30.0	25.0	2.4	4.30	0.2	-0.1	-1.6	4.0
30.0	30.0	2.4	4.36	0.5	0.3	-1.5	4.9

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 17							
0.0	0.0	-0.3	5.40	2.1	-0.2	-0.2	-0.1
0.0	-5.0	-0.3	5.39	1.9	-0.7	0.2	-0.8
0.0	-10.0	-0.3	5.39	2.0	-1.3	0.2	-2.1
0.0	-15.0	-0.4	5.32	1.7	-2.0	0.6	-3.2
0.0	-20.0	-0.6	5.60	1.6	-2.4	0.0	-4.0
0.0	-25.0	-0.6	5.58	1.5	-2.7	-0.5	-4.8
0.0	-30.0	-0.7	5.24	1.4	-2.7	-0.6	-5.6
0.0	0.0	-0.3	5.45	2.0	-0.3	-0.5	-0.1
0.0	5.0	-0.3	5.39	2.0	0.3	-0.9	0.7
0.0	10.0	-0.2	5.48	2.1	1.1	-1.0	1.4
0.0	15.0	-0.2	5.37	1.7	1.7	-0.9	2.6
0.0	20.0	0.0	5.30	1.2	1.8	-0.1	3.9
0.0	25.0	-0.3	5.30	1.2	2.0	-0.2	4.6
0.0	30.0	-0.5	5.21	1.1	2.2	0.2	5.6

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 18							
-15.0	-0.0	-2.2	5.23	1.5	0.0	-0.1	-0.1
-15.0	-5.0	-2.1	5.33	1.4	-0.7	0.1	-0.7
-15.0	-10.0	-2.3	5.27	1.5	-1.4	-0.4	-1.8
-15.0	-15.0	-2.4	5.34	1.2	-2.0	-0.4	-2.5
-15.0	-20.0	-2.5	5.33	1.0	-2.5	-0.9	-3.5
-15.0	-25.0	-2.6	5.15	1.0	-3.1	-1.3	-5.0
-15.0	-30.0	-2.7	5.01	1.2	-2.9	-1.4	-5.7
-15.0	0.0	-2.0	5.42	1.9	-0.2	-0.3	-0.3
-15.0	5.0	-2.2	5.29	1.5	0.6	-0.7	0.5
-15.0	10.0	-2.1	5.34	1.4	1.4	-0.6	1.1
-15.0	15.0	-2.2	5.42	1.1	1.7	-0.3	2.0
-15.0	20.0	-2.3	5.24	0.9	2.2	0.7	3.4
-15.0	25.0	-2.4	5.03	0.6	2.5	1.2	4.7
-15.0	30.0	-2.7	4.91	0.6	2.8	1.0	5.5

AA	AY	L	D	PM	YM	RM	SF
RUN NO. 19							
30.0	-0.0	4.1	3.93	2.5	-0.6	-0.5	-0.4
30.0	-5.0	4.2	4.07	2.5	-1.1	-0.2	-1.2
30.0	-10.0	4.0	4.28	2.6	-1.6	-0.1	-2.0
30.0	-15.0	4.0	4.33	2.5	-1.9	0.0	-2.5
30.0	-20.0	3.8	4.44	2.5	-2.3	0.0	-3.3
30.0	-25.0	3.6	4.50	2.4	-2.9	0.1	-4.3
30.0	-30.0	3.4	4.45	2.2	-3.0	0.1	-5.3
30.0	0.0	5.8	3.04	2.6	-0.6	-0.5	-0.5
30.0	5.0	5.7	3.14	2.7	-0.2	-0.8	0.4
30.0	10.0	4.1	4.25	2.5	0.6	-0.6	1.2
30.0	15.0	4.0	4.46	2.3	1.2	-0.2	2.1
30.0	20.0	4.0	4.54	2.4	2.2	0.2	3.3
30.0	25.0	3.9	4.57	2.1	2.7	0.0	4.4
30.0	30.0	3.8	4.97	2.2	4.5	0.1	5.9

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